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ABSTRACT

A project was conducted to develop solar energy installers curriculum guides for use in high school vocational centers and community colleges. Project activities included researching job competencies for the heating, ventilation, and air conditioning industry and determining through interviews and manufacturers' literature what additional competencies were needed to add solar to the industry. Career ladders were developed from existing industry levels of success. Formulation of measurable course objectives was implemented through conducting literature searches of varied manufacturers application engineering manuals, installation manuals, government publications, industrial publications, unions, etc., and existing public books. Instructional resources were identified by sending requests to all manufacturers, contractors, industry-related sources. As a result of the project, twenty units of instruction were developed in six areas: (1) Solar Application Installation, (2) HVACS Electrical, (3) Backup Heating Systems, (4) Refrigeration Theory, (5) Refrigeration Service Procedures, and (6) Heat Transfer Methods and Systems. (Consultant Reports are appended.) (LRA)

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ED189389

Final Report

# SOLAR ENERGY INSTALLERS CURRICULUM GUIDES
R-33-10-X0442-316

Gene C. Walker - Project Director
Technology Division
Air Conditioning-Regrigeration-Heating Department
College of DuPage
Glen Ellyn, Illinois

Sponsored by:

STATE BOARD OF EDUCATION
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DEPARTMENT OF ADULT, VOCATIONAL, AND TECHNICAL EDUCATION

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Springfield, Illinois

June 1980

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# FOREWORD

The College of DuPage, Technology Division, Air Conditioning/ Refrigeration Department, is pleased to present: SOLAR ENERGY INSTALLERS CURRICULUM GUIDES.

These guides were developed to be used as a basis to develop a Competency-Based Solar Energy Education Program for the training of individuals needed for the installation of solar energy equipment.

A special thanks to Richard R. Miller, Director of Development, for his assistance and advice; Patricia Polonus for sharing her typing skills; and Lucille Edwards for her assistance in literature searches through our Learning Resources Center.

## ABSTRACT

Title: SOLAR ENERGY INSTALLERS CURRICULUM GUIDES 80-133-4.4.2-A

Principal Investigator: Gene C. Walker, Coordinator
Air Conditioning/Refrigeration

Institution: College of DuPage

Location: 22nd Street and Lambert Road, Glen Ellyn, Illinois 60137

Objectives of Project:

1. Determine job competencies for solar energy installers, including minimum competencies for job entry.
2. Determine career ladders and criteria for promotion.
3. Formulate measurable course objectives.
4. Determine teaching and evaluation strategies for each objective.
5. Identify instructional resources.

Procedures of Implementation:

Project Director, Gene Walker, Coordinator of Air Conditioning and Refrigeration, will be responsible for following the time schedule to complete the stated project objectives. The project will begin the fall quarter, September 1, 1979, and will finish by June 30, 1980. By this date, the final report will be submitted indicating job competencies, career ladders, criteria for promotion, measurable objectives, teaching and evaluation strategies for each objective, and a listing of instructional resources. The Solar Energy Installer Program will be field-tested the fall quarter of 1980.

Contribution to Vocational and Technical Education

A Solar Energy Installers Program will be developed which will provide necessary training for manpower needs in solar energy.

## Products to be Delivered

Seven hundred fifty (750) copies of the final product (Phase II) will be mailed to the Research and Development Section of ISBE/DAVTE along with twenty (20) copies (Phases I and II) of the final report.

# PAID PARTICIPANTS

## Personnel Qualifications for Project Staff

### A. Project Director

Gene Walker, our coordinator for Air Conditioning and Refrigeration, College of DuPage, Glen Ellyn, Illinois, 60137, has been with the institution as a full-time instructor since September, 1976. Prior to his full-time employment, he taught part time. From 1965 to 1973, he was employed as a serviceman. From 1973 to 1976 Gene was a Systems Designer and Service Engineer for Dacor Heating and Cooling Company. He has developed several courses and attended numerous seminars and workshops on solar energy.

DEPARTMENT OF ADULT, VOCATIONAL, AND TECHNICAL EDUCATION

Funding Agreement Number: R-33-10-X-0442-316

# SOLAR ENERGY INSTALLERS CURRICULUM GUIDES

Project Director - Gene C. Walker
College of DuPage
22nd Street & Lambert Road, Glen Ellyn, Illinois 60137

August 1, 1979 - June 30, 1980

# I. INTRODUCTION

## A. Why Solar Energy

As we look at the ever-increasing cost of energy and lack of availability of fossil fuel, alternate energy sources become "necessity-mother of invention." Solar energy technology has existed for hundreds of years but expense was the main deterrent to its further development. In today's economy, cost is becoming less and less of a basis for decisions to go to an alternative energy source. Total lack of availability of cheap energy is fast becoming a reality, and those who have the foresight to develop alternate energies now and institute their use will be far ahead in the near future.

## B. Solar Energy Technician

Needs for trained installers and service persons is a never-ending requirement for any mode of the Comfort Conditioning Industry.

Employment needs for solar energy technicians (SET's) were derived from (1) U.S. Department of Energy estimates of the current and projected number of solar homes in the United States; (2) the number of year-round housing units in Illinois; and (3) the average amount of time required to design, install and maintain solar space and water heating systems. The U.S. Department of Energy estimates that there are 40,000 solar homes in the United States at the present time and that there will be 2.5 million solar homes by 1985.[1] This represents an 80 per cent annual increase in the number of solar homes; by 1983 there will be approximately 750,000 solar homes in the country.

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[1] Research Institute Recommendations, Vol. 29, No. 33. New York: The Research Institute of America. August 18, 1978.

Illinois accounts for 5.5 per cent of the year-round housing units in the United States[2]. Assuming it is representative of the rest of the United States in its current and projected use of solar energy for home heating purposes, it was estimated that within Illinois there are currently 2183 solar homes and by 1983 there will be 41,250 solar homes in the State. During 1983, 18,333 solar heating systems will be installed in homes in Illinois.

To estimate the employment impact of this increase in the use of solar energy for home heating, figures from a Navarro College study of solar energy technology were used[3]. That study determined that the expected time required to design, install and maintain solar home heating systems was 10, 40, and 2 hours, respectively. The total design and installation time of 50 hours was divided into the number of work hours in a person-year (2080) in order to determine the number of solar heating systems that one SET could handle in a year (41.6). By dividing the number of systems that would be installed during the year 1983 (18,333) by the number of systems which one SET could design and install (41.6) an estimated 441 full-time SET's will be needed in 1983.

The number of SET positions which will be needed in 1983 in order to maintain the 41,250 solar heating systems was derived by multiplying the number of systems which will be in operation (41,250) by the number of hours per year required to maintain each system (2).

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[2] Census of Housing, Vol. I. U.S. Bureau of the Census, 1970.

[3] Navarro College, Assessment of Need for Developing and Implementing Technical and Skilled Worker Training For the Solar Energy Industry, Navarro College, Corsicana, Texas, January 1978.

This resulted in 82,500 SET hours needed for maintenance of systems in 1983. By dividing the number of hours required for maintenance (82,500) by the number of work hours in a person-year (2,080), it was estimated that an additional 40 full-time SET's will be needed to maintain solar heating systems. When added to the number of SET's required to design and install systems (441), a total of 481 SET's will be needed by 1983.

To estimate the growth from present SET employment, it was assumed that all of the 2,183 existing solar homes were built in 1978. The number of SET's required to design, install, and maintain the systems this year will be 55. Thus, the growth in SET employment from 1978 to 1983 is estimated to be 426.

The replacement rate for SET's was obtained by using the rate for plumbers and pipefitters, which is estimated to be 10 per cent over for the next five years[4]. This figure was applied to the 1978 SET employment of 55 to yield five additional positions needed due to replacements. Thus, the total growth and replacement needs for SET's between 1978-1983 is estimated to be 431.

The regional distribution of solar energy technicians in Illinois was assumed to follow that of plumbers and pipefitters. The figures used to estimate regional distribution of SET's is presented in Table 9.

## Halfway House Residence Manager

The estimation of employment demand for HHRM was based on the assumptions that (1) halfway house growth would be positively related to the present location of halfway houses, (2) the average tenure of HHRM's is two years, and (3) halfway houses would increase at the rate of ten per year. The number of halfway houses known to the state agencies contacted was 97. The replacement of the managers of these facilities would require 242 new HHRM's. Growth of halfway houses over the next five years would require 50 additional managers. It was further assumed that at least eight of these 50 managers would be replaced by 1983. Thus, the total number of openings for HHRM's by 1983 is estimated to be 300.

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[4] Illinois Manpower Projections, op. cit.

The regional estimates were based on the proportion of halfway houses presently within each region. The proportion of 72 halfway houses (for which addresses were readily available) within each region was multiplied by 300. This operation yielded the estimated demand for HHRM's by region. The regional estimation procedure is presented in Table 10.

## Table 9

## Derivation of Projected Five-Year Employment Requirements for Solar Energy Technician

| Region | Plumbers/ Pipefitters | Percent of Total Employment | Total Demand (1978-1983) |
|---|---|---|---|
| 1 | 1064 | 4.19 | 18 |
| 2 | 16305 | 64.14 | 276 |
| 3 | 401 | 1.58 | 7 |
| 4 | 655 | 2.58 | 11 |
| 5 | 316 | 1.24 | 5 |
| 6 | 1047 | 4.12 | 18 |
| 7 | 292 | 1.15 | 5 |
| 8 | 1069 | 4.21 | 18 |
| 9 | 260 | 1.02 | 4 |
| 10 | 527 | 2.07 | 9 |
| 11 | 811 | 3.19 | 14 |
| 12 | 184 | 0.72 | 3 |
| 13 | 1188 | 4.67 | 20 |
| 14 | 213 | 0.84 | 4 |
| 15 | 169 | 0.66 | 3 |
| 16 | 85 | 0.33 | 1 |
| 17 | 411 | 1.62 | 7 |
| 18 | 94 | 0.37 | 2 |
| 19 | 131 | 0.52 | 2 |
| 20 | 197 | 0.77 | 3 |
| Total | 25,419 | 100.00 | 431 |

Note: Rounding may cause discrepancies in totals.

## Solar Energy Technician

Association of Plumbing, Heating, and Cooling Contractors, Inc., Rockford, Illinois

Century Solar Engineering, Bensonville, Illinois

Colorado State University, Fort Collins, Colorado

Illinois Association of Heating, Plumbing, and Cooling Contractors

Illinois Department of Business and Economic Development, Division of Energy, Springfield, Illinois

Illinois Institute of Technology, Chicago, Illinois

Oak Ridge Associated Universities; Manpower Education, Research and Training Division; Oak Ridge, Tennessee

Plumbers and Pipefitters Union, Local No. 99, Bloomington, Illinois

Solar Construction Company, Wood Dale, Illinois

Solar Division of International Harvester, Chicago, Illinois

Solar Dynamics, Northfield, Illinois

Solar Products, Rockford, Illinois

U. S. DOE, formerly Energy Research and Development Administration Office, Chicago, Illinois

U. S. DOE, Manpower Assessment Program; Education Programs Division; Washington, D.C.

## Need for Curriculum Guides

The need for curriculum guides for training of solar installers was made apparent when College of DuPage's HVAC Program Coordinator started to research the availability of existing course guides.

Since the time that a need was determined, June, 1978, several manufacturers of solar products have come out with their own guides and many schools have developed programs--as indicated in Illinois Solar Energy Directory, page 83: Solar Energy Education Programs in Illinois. However, on page 92, Energy Education Materials, under Curriculum Aids, there is no listing of a guide for solar installers.

The manufacturers' manuals are slanted toward their own product--deservedly so--and the other institutional programs are mostly oriented toward consumers and design engineers.

These findings made it apparent that a Solar Installer's Guide which consolidated all installation procedures in a step-by-step manual was needed.

## ACCOMPLISHMENTS

The development of SOLAR ENERGY INSTALLERS CURRICULUM GUIDES was conducted to make available to K-11-14 postsecondary schools a viable guide to follow in developing a State-approved air conditioning-refrigeration-heating-solar curriculum.

The objectives of the project were:

1) To determine job competencies for solar energy installers, including minimum competencies fo job entry.

2) To determine career ladders and criteria for promotion.

3) To formulate measurable course objectives.

4) To determine teaching and evaluation strategies for each objective.

5) To identify instructional resources.

The objectives were implemented by:

1) Researching existing job competencies for HVAC industry and determining through interviews and manufacturers' literature what additional competencies, if any, were needed to add solar to the industry. After competencies were developed, they were scrutinized by an advisory board made up of people from HVAC industry (contractors, wholesalers, manufacturers), former students, faculty members, and administration -- people directly involved in installation of solar products today. Revisions and additions were made. Competencies were also gone over with the Director of Instructional Design.

2) Career ladders were developed from existing industry levels of success. It was felt by the Project Director that the ladders developed by SIU in their "Development of a Training Program for the Installation of Solar Energy Systems in Residential Buildings" needed to be expanded into more definite levels. Unions involved in sheet metal and pipe-

fitting were consulted as to their apprentice promotion ladders on up to management or ownership. After development of ladders, another advisory board meeting was called and the career ladders were finalized. These were approved by the Director of Instructional Design and the Project Director.

3) Formulation of measurable course objectives was implemented through conducting literature searches of varied manufacturers' Application Engineering Manuals, Installation Manuals, government publications, industrial publications, unions, etc., and existing public books. Total course objectives were discussed with individual advisory board members and the Director of Instructional Design. Finalizing of course objectives was done after determining that all realms solar installation for the HVAC industry had been covered.

4) Determining teaching and evaluation strategies for objectives was developed from existing and proven methods being used in College of DuPage's Air Conditioning, Refrigeration, Heating Program. College of DuPage's HVAC Program is noted across the United States and in several other countries as a high-quality industry training agent.

5) Instructional resources were identified by sending requests to all manufacturers, contractors, industry-related sources for any existing publications that could be recommended for instructional use. The response was a bombardment of installation and engineering manuals and recommendations on what published books to use. A total literature search was done by our Associate Director of Utilization through College of DuPage's Learning Resources Center.

The contribution to Vocational and Technical Education is a model Solar Energy Installers Program which will provide necessary training for manpower needs in solar energy. This program is competency-based and can be adapted for use in grades K-11-14. All necessary texts, audio-visual and solar materials to present these programs have been listed in each guide, along with tests to evaluate student performance.

The products to be delivered are 20 copies of Phase I final report filed with the Research and Development Section contract administrator and 20 copies of Phase II final report.

The Main Product will be THE SOLAR ENERGY INSTALLERS CURRICULUM GUIDES.

## OBJECTIVES

The first main objective was the development of the following job competencies. These were revised by the first advisory board meeting and by Mr. Boyd: (Please see next page.)

# COMPETENCIES

These competency statements are developed with the understanding that all solar systems in the State of Illinois will need to be integrated with back-up systems. A total knowledge of all systems will create the most desirable heating, air conditioning, ventilation, refrigeration, and solar installer and technician.

Minimum competencies for starting into the heating and air conditioning field:

- Tenth grade education completed.
- Demonstrate capabilities to add, subtract, multiply and divide.
- Demonstrate understanding of the metric system.
- Demonstrate ability to communicate with others.
- Read English and demonstrate an understanding of materials read.
- Demonstrate writing skills others can comprehend.
- Demonstrate physical capability--to be determined according to job skills required to perform satisfactorly
- Demonstrate being mechanically inclined--being able to work well with hands as well as with mind.
- Demonstrate neatness--being exact (taking pride in a job well-done.)

Students from grades 4 to 10 will be advised to take technology courses that pertain to development of the aforementioned competencies. At this point in time very few high schools are involved with programs that teach heating, air conditioning, ventilation, refrigeration. There are several schools working on this problem, but until they have their curriculum developed, this curriculum now being developed can be taught at a high school level.

## A. ENERGY CONSERVATION COST FOR DIFFERENT ENERGIES AND POSSIBILITY OF GOING TO ENERGY STANDARD CONSERVATION

1. Demonstrate understanding and evaluate energy conservation measures involved with heating and cooling systems.
    - a. Demonstrate understanding and evaluate efficient thermostat settings for heating and cooling (night set back).
    - b. Demonstrate by explaining the net comfort effects of using humidifiers and dehumidifiers to raise or lower comfort in areas.
    - c. Demonstrate understanding and evaluate the use of lower heat and cooling settings for shut down or unoccupied buildings.
    - d. Demonstrate familiarity with the proper fan speed for room air conditioners on humid days.
    - e. Demonstrate understanding of the main contributions of internal heat gain in a building and the use of this heat gain (people, lighting, machines).
    - f. Demonstrate the understanding of the purpose of maintenance and replacement schedules for system air and fuel filters.
    - g. Demonstrate by explaining how cleaning HVAC air and water cooled condensors can improve operating efficiency.
    - h. Demonstrate understanding of the purpose and function of a $CO_2$ flue gas analysis and its need for peak combustion efficiency.
    - i. Demonstrate understanding of the effects of insulating ductwork.
    - j. Demonstrate understanding of the effects of installing ductwork in conditioned as opposed to the unconditioned space.
    - k. Demonstrate understanding of the effects of closing duct outlets in unused rooms.

   l. Demonstrate understanding of the effects of improper ductwork sizing and improper location of appendaces.
   m. Demonstrate understanding of the effects of zone heating and cooling.
2. Define the energy conservation measures involving outside structure walls.
   a. Describe effects of thermal insulation in stud space.
   b. Describe the effects of including a vapor barrier between insulation and conditioned space.
   c. Describe the effects of using insulated sheathing.
   d. Describe the effects of using insulated sheathing with a radiation barrier.
   e. Describe the effects of unconventional framing (2 x 6 studs 24" OC, etc.).
   f. Describe the effects of adding insulated or insulating exterior siding.
3. Demonstrate understanding of energy conservation measures involving roofs.
   a. Describe the effects of installation of ventilation devices in roofs or attics.
   b. Describe the effects of placing a vapor barrier between the insulation and conditioned space in roof areas.
   c. Describe the effects of insulating the ceiling and roof areas.
4. Demonstrate understanding of energy conservation measures to combat infiltration in homes and commercial businesses.
   a. Describe the effects of caulking around door and window casings.

   b. Describe the effect of caulking under sole plates and around plumbing and electrical wiring holes in new construction.
   c. Describe the effects of weatherstripping around exterior openings.

5. Define energy conservation measures involving glazing.
   a. Describe the effects of reducing glass areas on north and west sides of buildings.
   b. Describe effects of storm windows.
   c. Describe effects of insulating and thermal glazing.
   d. Describe effect of multiple glazings.
   e. Describe the pros and cons of fiberglass glazing or petrochemical glazing vs. silica-fused glazing.
   f. Describe the effects of external shading (shade screens, shutters, awnings, overhead projections, bead wall).
   g. Describe the effects of internal shading (draperies, blinds, roller shades, etc.)
   h. Describe the effects of removable insulated panels.

6. Demonstrate understanding of energy conservation measures involving floors.
   a. Describe the effects of thermally insulating exterior surfaces of concrete slab perimeters.
   b. Describe the effects of insulating the inside surface of perimeter beams and insulating several feet under floor for concrete slab construction.
   c. Define the effects of closing crawl space vent openings during winter.
   d. Describe the effects of thermal insulation under floors.

7. Define and evaluate energy conservation measures involved with water systems.
    a. Evaluate the installation of a pressure reducing valve in the main water supply for water systems pressurized over 40-50 lbs.
    b. Describe the energy savings of using flow restrictors in water systems.
    c. Describe the energy conservation effects of lowering temperature settings on hot water heating.
    d. Demonstrate by discussing the advantages and disadvantages of using timers on hot water heaters to turn heating elements off during periods of the day in which no hot water is needed and to allow water to be heated during off peak hours and stored for peak hour usage.
    e. Describe the need to periodically drain sediment and clay from water tanks.
    f. Explain the net energy loss from leaky faucets.
    g. Define the energy savings of using spring activated water taps.
8. Define and evaluate energy conservation measures involved with lighting systems.
    a. Demonstrate by discussing the energy consumption, light quality, lumens per watt, the advantages and disadvantages of various lighting sources such as incandescent, flourescent, metal halide, low pressure sodium, high pressure sodium and mercury vapor lighting systems.
    b. Describe the importance of reducing wattage of incandescent bulbs when possible.

c. Be able to evaluate the rows of lights for multiple electrical switching so lights near natural light sources may be turned off when light is sufficient.

d. Describe the importance of regular cleaning of lighting tubes and encasements to prevent dust and dirt accumulation.

e. Describe the need to lower lights in areas with high ceilings.

f. Describe the need to use light colored paints in lighted areas to increase reflection and reduce lighting requirements.

g. Explain the pros and cons of using mirrors, lenses, reflective coating, diffusers, polarizers, to distribute light efficiently.

h. Be able to evaluate an area for task lighting.

i. Define and discuss the purpose for regular lamp replacement in flourescent lighting systems and the total effect on energy consumption.

9. Demonstrate understanding of the energy conservation measures on internal electrical appliances and devices.

a. Describe the energy loss connected with ventilation fans such as range hoods and bathroom fans.

b. Define and discuss energy conservation measures in storage of refrigerated and frozen foods.

c. Define and discuss energy conservation measures when using washers and driers.

d. Define and discuss energy conservation measures in use of dishwashers.

e. Define and discuss energy conservation measures in cooking and using electrical ranges, microwaves, pressure cookers, etc.

10. Define and evaluate energy conservation measures involved in equipment purchasing and maintenance.
    a. Compute life cycle cost of equipment and evaluate the economics of purchasing based on these costs.
    b. Evaluate the energy savings of purchasing multiple speed motors or variable speed drives for various equipment loads.
    c. Describe the excess electrical consumption of overloaded equipment.
    d. Evaluate the rewiring of major machinery from 120 volts to higher voltage and discuss how this can save energy.
    e. Describe the need to properly lubricate-oil moving parts of equipment.
    f. Describe the need to perform preventive maintenance on equipment.
    g. Describe the purpose and energy savings of regularly cleaning electric motors from cobwebs and dust to improve efficiency.
11. Demonstrate understanding of the energy conservation measures of fireplaces.
    a. Describe the net heating effect of fireplaces taking into account the air and combustion requirements.
    b. Describe combustion requirements for fires.
    c. Describe the effects of combustion air ducts (internal and external).
    d. Describe the effects of air infiltration and fireplaces.
    e. Describe the effect of sdaled doors on a fireplace.
12. Demonstrate understanding of the energy conservation effects of other miscellaneous measures.
    a. Define the proper clothing requirements to save energy during heating and cooling periods.
    b. Describe the effects of deciduous shading in summer and winter.

B. INTRODUCTION TO SOLAR ENERGY AND EMERGING ENERGIES

1. Define historical aspects of solar energy.
    a. Ancient uses and methods of converting solar energy.
    b. Go over mistakes made in the past that we have learned from.
2. Demonstrate understanding of current solar technology.
    a. Active and passive solar energy systems.
    b. Practical applications and proven hardware and conversion methods (domestic hot water, space heating, swimming pool heating, space cooling, and agricultural and industrial applications).
3. Describe emerging solar techniques, applications, and developments.
    a. Comprehend theory of the following (solar photovoalatic cells, space power stations, microwave transmissions, solar farms, and sea thermal energy).
4. Demonstrate understanding of other current and projected sources of energy (pros and cons).
    a. Nuclear fusion
    b. Nuclear fission
    c. Coal Technology (burning, gassification, liquidification).
    d. Petrleum distillates and by-products
    e. Natural gas
    f. Shale oil
    g. Methane-biogas
    h. Tar sands
    i. Wind
    j. Wood (Pellets, fluidized beds-gassification)
    k. LNG
    l. Geopressurized gas
    m. Geothermal

   n. Biomass and alcohol conversion
   o. Wave
5. Describe United States and world energy demands vs. supplies.
6. Describe United States energy situations and move for energy independence.
7. Describe current status of solar industry (manufacturers and manpower needs).
8. Describe the United States balance of trades and the effect petroleum purchasing has on this balance.

C. SOLAR RADIATION

1. Describe the physical characteristics of the sun (size, temperature, distance from the earth, reusable energy).
2. Demonstrate understanding of the factors affecting the path of radiation through the atmosphere.
   a. Angle of incidence (latitude, time of year, time of day).
   b. Altitude
3. Demonstrate understanding of the physics of radiation reaching the earth's atmosphere.
   a. Understand the time factor.
   b. Understand the solar radiation constant.
   c. Understand physics of solar radiation and light (ultraviolet, visible, and infrared).
4. Describe the physics of radiation reaching the earth's surface.
   a. Characteristics of direct vs. diffuse radiation.
   b. Factors affecting diffusion of direct radiation (moisture, clouds, haze, dust, smog, etc.).
5. Describe the average daily radiation and the waather service charts depicting this information, how to read and interpret.

6. Define the factors affecting the proper collector tilt (solar noon, azimuth angle, sun altitude).

D. SOLAR ENERGY SYSTEM DESIGN

1. Describe the arrangement of equipment, ductwork, piping, and operating control modes for liquid systems.
    a. Domestic hot water only.
    b. Space heating and domestic hot water.
    c. Space heating, domestic hot water, and swimming pool heating.
    d. Space heating, space cooling, and domestic hot water.
2. Describe the arrangement of equipment, ductwork, piping, and operating control modes for liquid systems with freeze protection (heat exchangers, drain down, pump pulse).
3. Describe the arrangement of equipment, ductwork, piping, and operating control modes for air systems.
    a. Domestic hot water air system.
    b. Domestic hot water and space heating system.

E. COLLECTORS

1. Demonstrate understanding of the pros and cons of the various types of collectors.
    a. Flat plate types (air, liquid, evacuated tuve).
    b. Concentrating types (parabolic, parabolic trough, stationary reflector tracking absorber, fernel lens, and heliostats).
    c. Photovotaic cells.
2. Demonstrate the applications of collectors and the best type of collector for specific purposes.
3. Define the basics of collector performance.
    a. Define variables affecting energy absorbed by the collector such as incident radiation on collector surface, transmissivity of glazing, and absorber variables.

b. Demonstrate understand of the heat losses of collectors (conduction, radiation, convection) and the losses from various parts of the collector.

c. Perform experiments to emphasize the effect of collector glazing and heat loss (single vs. double glazing).

4. Describe the use and purpose of collector components.

F. SOLAR AIR SYSTEMS

1. Define the various types of metal and fiberglass ductwork and the pros and cons of each type.
2. Describe the purposes of insulating air distribution systems for both thermal and sound control.
3. Describe the purpose of a good air distribution system.
4. Describe the purpose of various air system supply and return devices such as registers, grilles, and diffusers.
5. Define the dampers and damper motors used in air systems.
6. Define various parts of air distribution systems that resist air movement such as heat storage units, coils, filters, registers, grilles, diffusers, and ductwork.
7. Defind types of centrifugal fans and their performance criteria (forward curved, radial, and backward curved).
8. Demonstrate use of airflow meters and temperature controls used in air systems.

G. SOLAR HYDRONIC

1. Demonstrate the types of pumps, their selection and purpose in application to hydronic systems, sizing very important.
2. Define the types of pipes and fittings used in hydronic systems.
3. Descrive the purpose of the various valves used in hydronic systems.

4. Demonstrate the understanding of various types of heat exchangers used in hydronic systems and the selection criteria for each type.
5. Describe the purpose for expansion tanks in a hydronic system and be familiar with the various types of expansion tanks, their locations, and the sizing criteria.
6. Describe the purpose of other accessories in a hydronic system such as air vents, strainers, balancing valves, regulators, pressure and temperature relief valves, vacuum relief valves, etc.
7. Demonstrate being familiar with flow, pressure, and temperature instruments used in hydronic systems.

## H. HEAT EXCHANGERS

1. Explain the purpose and function of air type and water type heat exchangers.
2. Explain the construction and pros and cons of the following types of heat exchangers; shell and tube, shell and double tube, double wall, and parallel tube heat exchanger.

## I. STORAGE

1. Explain the pros and cons of the various heat storage methods (liquid, solid, phase change, Eutectic salts).
2. Describe latent heat and sensible heat and examples of storage medium utilizing these methods.
3. Explain the purpose of insulating storage areas.
4. Define the various materials used to construct heat storage systems.

## J. SOLAR ENERGY COOLING

1. Describe the theory and define system components of the Triethylene Glycol open cycle system.
2. Describe the theory and define system components of the absorption system cooling basic cycle.

3. Describe the theory and define system components of the rankine cycle vapor compression system.
4. Describe rock bed evaporative cooling and radiative cooling.

K. SOLAR ENERGY CONTROLS

1. Demonstrate the purpose, construction and operation of a relay.
2. Demonstrate the purpose, construction, and operation of a low voltage transformer.
3. Demonstrate the purpose, construction and operation of an electrically powered solenoid valve.
4. Demonstrate the purpose, construction, and operation of an electrically powered multi-blade damper.
5. Demonstrate the purpose, construction and operation of various controls used to activate component parts of a solar energy system (two stage low voltage thermostate, outdoor thermostate, differential controller, outdoor reset controller).
6. Demonstrate the purpose, construction, and operation of various sensors used to initiate electrical impulses (bimetal sensor, bellows/diaphram sensor, thermistor sensors.)

L. BLUEPRINT READING

1. Demonstrate ability to interpret architectual drawings and specifications.
2. Demonstrate ability to determine equipment sizings from architectural drawings.
3. Define, interpret and understand isometric and 3-view machine drawings.
4. Demonstrate ability to sketch pictorially.
5. Demonstrate methods of sketching in proportion.

M. HEAT LOSS/HEAT GAIN CALCULATIONS

1. Calculate the residential heating and cooling loads using the ASHRAE residential procedure or NESCA or IBR and the utility and manufacturers company short form methods.
2. Review the ASHRAE procedures for calculating heating and cooling loads for commercial buildings.

N. SAFETY

1. List the six classifications of accidents in the HVAC shop (mechanical causes, electrical shocks, high pressure, burns and scalds, explosions, and breathing toxic gases).
2. Demonstrate understanding of electrical safety rules.
    a. Major causes of electrical accidents.
    b. Safety rules for using electrical tools and test equipment
    c. Electrical rescue procedures and first aid.
3. Define refrigerant safety rules and proper storage and handling procedures.
4. Describe safety precautions for handling gas and pressurized refrigerant cylinders.
5. Define safety precautions using the highly flammable gases used in the trade (propane, propylene, ethane, ethylene, methane, isobutane, acetylene).
6. Define safety rules for using air acetylene and oxacetylene torches.
7. Define safety precautions for handling large pieces of glass.
8. Define safety rules involving fire and its hazards.
    a. The fire triangle
    b. Classes of fires and the type of extinguisher used to contain these fires.

9. Define rules for general shop safety.
10. Define the steps and procedures to maintain a clean and orderly shop.
11. Define the steps to follow in case of an accident in the shop.
12. Describe personal safety rules involving clothing, personal hygiene, and conduct.
13. Define steps for lifting heavy objects.
14. Define safety rules related to working on pitched roofs.
15. Define safety rules for using ARC welding equipment.
16. Demonstrate federal safety colors and applications of the safety color code.
17. Define all OSHA rules pertaining to heating, air conditioning, ventilating trades.

O. INSTALLATION (SOLAR ENERGY)

1. Verify large/small system, read installation manual.
2. Mount and install major items.
   a. Install auxillary conventional furnace (see HVAC Competencies).
   b. Install domestic hot water tank (water systems)
   c. Install and connect pipe to the following hydronic components (hydronic systems). (Heat exchangers - liquid to liquid and air to air to liquid; pumps, expansion tanks, air vents; strainers; balancing valves; regulators; pressure and temperature relief valves; control valves; flow; temperature and pressure sensors and meters; thermal insulators; vacuum relief valve).

   Install the following air distribution components (air systems): (ductwork, sheetmetal and fiberglass, see air distribution;

competencies; supply and return devices, registers; grilles; and diffusers; thermal and sound insulation; blowers; water to air heat exchangers; piping.

- d. Flush, fill and purge hydronic systems.

  Insulate pipes or ductwork.

3. Install collectors
   - a. Shop test all components for leaks before assembly.
   - b. Prepare/construct collector mounting foundation (roof or free standing), and check and wind leads.
   - c. Construct and install collector mountings.
   - d. Mount collectors
   - e. Install collector temperature sensors.
4. Construct/install storage system.
   - a. Check tank for leak.
   - b. Insulate storage container.
   - c. Prepare foundation.
   - d. Install or construct storage or preheat container (liquid and/or rock).
   - e. Install internal container components (rocks, heat exchangers).
   - f. Install storage temperature sensors.
   - g. Construct connections to system (air and water).
5. Install and connect electrical controls and wire the total system.
   - a. Make electrical connections to the following: controls; thermostats; sensors; pumps; blowers, auxiliary heating; control valves and dampers.
   - b. Install thermostats.
   - c. Install main controls.

    d. Install remaining sensors.
    e. Connect to main control panel.
    f. Possible micro-process to handle wiring diagram-programming.

6. System checkout and startup.
    a. Perform visual inspection of overall system.
    b. Check placement of sensors, control devices, and wiring.
    c. Check equipment for proper position, support, and service access.
    d. Pre-test clean and flush.
    e. Start up system to perform other checkout procedures.
    f. Check the following for hydronic systems: solution charge, antifreeze or solution concentration, flow rates, pressures, operation of safety valves, leaks.
    g. Check the following for air systems: leaks, flow rates, damper operation.
    h. Fine tune the system for peak performance.
    i. Check system performance with actual design criteria.
    j. Make customer aware of how to operate system.

## P. EVALUATING SOLAR ENERGY SYSTEM PERFORMANCE

1. Measure various system temperatures using thermometers, thermocouples, thermistors, etc.
2. Use an insulation meter to measure solar energy available at collector surface.
3. Use a velometer, pitit-tube and manometer, anemometer, etc. to measure air flow.
4. Determine air density by measuring with a dry bulb, wet bulb.
5. Use a flow meter to measure liquid flow.
6. Measure liquid density with hydrometer.
7. Evaluate system performance from measured data.

## Q. MAINTENANCE (SOLAR SYSTEM)

1. Perform routine maintenance of solar energy systems.
   a. Check condition and operation of all system components.
   b. Check tracking orientation of concentrating collectors.
   c. Replace system components which are periodically consumed.
   d. Flush storage tanks to remove dediment.
   e. Descale heat exchangers (water side).
   f. Check fluid levels, flow rates, and solution concentrations (flush and refill if necessary).
   g. Lubricate moving parts.
   h. Check motor belts for tension and alignment.
   i. Change or clean all filters.
   j. Check and adjust air flow through air handling unit.
   k. Check controls, wiring, and proper mechanical operations in various modes.
   l. Check glazing to be sure it is free from obstructions (paper, glass, dirt).
   m. Check condition of insulation (piping, storage, ductwork).

## R. TROUBLESHOOTING AIR SOLAR SYSTEM

1. Troubleshoot system that has no air flow.
   a. Check blower motor for power
   b. Check blower vains clean.
   c. Check duct work connections
   d. Check collector
2. Troubleshoot erratic operating systems.
   a. Check main regulating panel for proper installation of sensors and settings on controllers.

- b. Check all dampers for proper operation.
- c. Check all back-up systems for proper operation.

3. Troubleshoot for lack of enough hot air.
   - a. Check collectors for proper facing and angle.
   - b. Check controls for proper sensing and function.
   - c. Check storage for proper damper positioning.
   - d. Check for proper size storage and insulation.
   - e. Check duct work for heat loss.
   - f. Check air flow for proper movement rate and pressure.
4. Troubleshoot system with decreasing performance.
   - a. Check collector fir dirt, deterioration, absorber coating, cracks, bad seals, increased shading.
5. Troubleshoot for noisy system.
   - a. Check for air leaks in ductwork.
   - b. Check for proper lubrication of all components.
   - c. Check fan speed and belt adjustment and newness.

S. TROUBLESHOOTING HYDRONIC SOLAR ENERGY SYSTEMS

1. Troubleshoot systems that are frequently not in operation or in continuous operation.
   - a. Check differential thermostats for proper setting, installation, and mechanical or electrical operation.
   - b. Check sensors for proper installation and electrical operation.
2. Troubleshoot solar systems that have no fluid flow.
   - a. Check pump to see if the impeller is bound.
   - b. Make sure shutoff valves are working properly.
   - c. Check flow regulator for obstructions or improper installation.
   - d. Inspect system to see if it is air locked.

   e. Check pump installation.
   f. Inspect system for the proper number of vents.

3. Troubleshoot various system components for the problem of lack of enough hot water.
   a. Check collectors for improper face or slope, shade, insufficient design area, and unequal flow.
   b. Check differential thermostate for electrical connections, sensor locations, sensor mountings, faulty sensors, or faulty thermostats.
   c. Check the mixing valve for proper mechanical operation or improperly set temperature indicator.
   d. Check storage tank for size, electrical connections, storage heat loss.
   e. Check piping for heat loss.
4. Troubleshoot solar systems for decreasing performance.
   a. Check collectors for dirt, deteriorating absorber coating, cracks, deteriorating seals, or increased shading.
   b. Check storage tanks for sludge.
5. Troubleshoot solar systems for excessive noise.
   a. Check to make sure the system is not air locked.
   b. Check piping for trapped air.
   c. Check air purger for proper installation and operation.
   d. Check air vents for proper operation.
6. Troubleshoot various system components for the problem of water leaks.
   a. Check fittings at all locations.
   b. Check manufacturer collectors for leaks.
   c. Check pump bearing assembly.

7. Troubleshoot solar systems for pressure drops.
    a. Check pressure in the expansion tank.
    b. Check relief valves.
    c. Inspect for slow leaks in collectors and system piping.
    d. Check air vents.
    e. Check storage tank for a leak in the heat exchanger.

Other necessary knowledge to perform properly on total system.

AA. INSULATION

1. Describe the basic principles of heat transfer (conduction, convection, radiation.)
2. Review, discuss, and demonstrate an understanding of insulating values, terms, and heat loss coefficients (BTU, U, R).
3. Describe the proper areas of a structure to insulate and be familiar with minimum R values for energy conservation.
4. Define the pros and cons of various insulating materials.
    a. Describe loose fill insulation such as rock and glass wool, wood pulp products, and vermiculite.
    b. Describe blanket and batt flexible insulation.
    c. Describe rigid insulation such as fiberboard, building boards, wall boards, sheathing, and expanded polystyrene and urethane plastic foams.
    d. Describe reflective insulation such as aluminum foil, sheet metal with reflective coating, and paper products coated with reflective oxide composition.
5. Define the principles and purpose of vapor barriers and be familiar with condensation resulting from these barriers.
6. Demonstrate proper installation procedures for various types of insulation.

## BB. TOOLS USED IN THE HVAC TRADE

1. Identify, demonstrate the proper use and care for general hand tools used in the HVAC trade.
    a. Identify and demonstrate the proper use of the following general hand tools: screwdrivers, wrenches, pliers, hammers, chisels, punches, bars, files, socket sets, tubing tools, threading tools, and accessory hand tools used in the HVAC trade, and sheet metal tools.
2. Identify, demonstrate the proper use and care for specialized tools used in the HVAC trade.
    a. Identify and demonstrate the proper use of a refrigeration gauge set for charging, evacuating and checking pressures.
    b. Identify and properly use fin combs and the following sheet metal tools: combination and pattern snips, hand notcher, hand seamer, riveting and other hammers, right and left hand aviation snips, double cutting snips, hand crimper, dividers, drive turner, scratch awl, break, shear and pitsburg.
    c. Identify and select drill bits for wood, masonry and metal.
    d. Identify and properly use a bench vise and a pipe vise.
    e. Identify and properly use wheel, bearing, and gear pullers.
    f. Identify and state the use of pocket, remote bulb, flue and stack, and thermal thermometers.
    g. Identify and properly use a refrigeration ratchet.
    h. Identify and demonstrate the proper use of an electric recording thermometer.
    i. Identify and demonstrate the proper use of the following hygrometers; sling psychrometer, dial type hygrometer and humidity recorder.

   j. Identify and demonstrate the use of a low and a high vacuum pump triple and deep.
   k. Identify and properly use the following vacuum indicators: compound gauge, mercury manometer, and thermocouple micron gauge.
   l. Identify and properly use the following air meters: aneometer, pilot tube, and incline manometer.
   m. Identify and properly use a combusion testing kit.
   n. Identify and properly use electronic and halide leak detectors.
   o. Identify and properly use electrical hand tools, wire strippers, kleins, conduit bender, water pump pliers.

3. Identify, properly use, read, and care for measuring instruments used in the HVAC field.
   a. Identify, use, read, and care for rules used in the HVAC trade (combination square, folding rule, steel rule, circumferencr rule, steel tape), metric.
   b. Identify, properly use, read, and care for wire and drill gauges used in the HVAC trade.
   c. Identify, use, and care for slide, inside and outside calipers used in the HVAC trade.
   d. Identify, read, use, and care for inside and outside micrometers used in the HVAC trade.
   e. Identify, read, use and care for charging cylinders for measurement of fluorohydro carbons.

## CC. TUBING AND PIPING

1. Demonstrate an ability to distinguish between different types of tubing and fittings, and select the proper size and type of tubing and fittings needed for a particular application.

   a. Describe the various uses of copper, aluminum, steel, and glass tubing.
   b. Define the difference between nominal size copper tubing and ACR copper tubing.
   c. Define the difference between annelled and hard drawn copper tubing and state the proper use of each type.
   d. Describe the classification, specifications, and proper use of copper tubing in relation to wall thickness (K, L, M, DWV).
   e. Explain the use and identify the various types of fittings and valves for flare connections, compression connections, and sweat connections, swedge, threaded, epoxy.
   f. Identify various flare and splice hose fittings.
   g. Identify cutter type and spring loaded seal quick connect fittings.
   h. Describe the construction and use of flexible refrigerant hose.

2. Demonstrate the skill to properly use the tools and processes to cut, flare, bend, and swage tubing within various specifications.
   a. Identify and demonstrate the proper use of a tubing cutter and reamer.
   b. Demonstrate the ability to double and single flare a tube using a compression type flaring block.
   c. Demonstrate the ability to make a swage joint using a hand swage set and mechanical set.
   d. Demonstrate the ability to use an inside and outside spring type bender and a lever type bender to bend a 90° bend, a 180° bend, and a 45° offset bend.

3. Describe the HVAC uses of black iron, galvanized, and plastic pipe, and the fittings used with these pipes and be able to select the

proper type and size of pipe and fittings to serve in a particular application.

a. Define the uses of galvanized pipe in the HVAC trade and identify various fittings for iron pipe.

b. Define the uses of black iron pipe in the HVAC trade and identify various fittings for iron pipe.

c. Describe sizing specifications for black iron and galvanized pipe such as standard wall, extra strong wall, and double extra strong wall.

d. Define the use of cast iron fittings in hydronic heating.

e. Describe the difference and the application pros and cons of the four types of plastic pipe (ABS, PVC, CPVC, and PE).

f. Define the advantages and disadvantages of using plastic pipe in the HVAC trade.

g. Identify the various fittings for ABS, PVC, and CPVC pipe.

h. Identify the various fittings for flexible plastic pipe .

4. Demonstrate the skill and ability to size, cut, thread, and assemble black iron and galvanized pipe.

   a. Demonstrate the ability to cut iron or galvanized pipe using a wheel type cutter, ream the burs from the inside of the pipe using a spiral type reamer, and use a die stock and proper size die to thread the pipe.

   b. Assemble the threaded pipe in the proper fitting using the proper pipe wrenches and proper thread sealant.

5. Demonstrate the skill and ability to size, cut, ream and assemble plastic pipe using insert fitting joints and solvent joints.

## DD. SOLDERING, BRAZING AND WELDING

1. Demonstrate an understanding of safety rules when soldering, brazing and welding. Name and discuss the component parts of the air-propane torch, air-acetylene torch, high and low velocity, oxyacetylene torch, and the electric welder, and be able to light and adjust the air propane torch, air-acetylene torch, and the oxyacetylene torch.
   - a. Describe the purpose for, and safety equipment needed for, using gas welding and soldering equipment.
   - b. Define the purpose for, and safety equipment needed for, using electric welding equipment.
   - c. Identify the components, assemble, and state the purpose of the air-acetylene torch, high and low velocity.
   - d. Identify the components, assemble, and state the purpose of the air-propane torch.
   - e. Demonstrate the skill to safely light, adjust, and extinguish both the air acetylene torch and the air propane torch.
   - f. Demonstrate the skill to safely light, adjust and extinguish the halide leak detector.
   - g. Describe the proper cleaning procedure and care of the air acetylene and the air propane torch.
   - h. Identify, assemble, and state the purpose of the components of the oxyacetylene torch.
   - i. Demonstrate the skill to safely light, adjust and extinguish the oxyacetylene torch.
   - j. Demonstrate the proper cleaning procedure and care of the oxyacetylene torch.
   - k. Identify the components and state the purpose of the electric welder in climate control.

1. Demonstrate the proper cleaning procedure and care of the electric welder.

2. Demonstrate an understanding of types of soft solder and fluxes and demonstrate the proper skill and procedure to soft solder various types of swage joints.
   a. Define the purpose of cleaning and fluxing a solder joint and understand the pros and cons of fluxes (corrosive paste flux, and liquid self-cleaning flux).
   b. Demonstrate the proper use and explain the pros and cons of various sypes of soft solders (50-50, 95-5).
   c. Escribe the purpose of capillary action in a solder joint and the conditions and methods to create capillary action.
   d. Clean, flux, and solder the following joints using the air propane or the air acetylene torch: swage joint, inverted swage joint, horizontal swage joint.
   e. Clean, flux, braze, and solder a swage joint with the oxyacetylene torch.

3. Demonstrate an understanding of the types of silver brazing alloys and fluxes and demonstrate the proper skill and procedure to silver braze various types of swage joints.
   a. Define the types of characteristics of the different silver brazing alloys (AWS BAg-1, AWS BCuP-5, AWS BCuP-3).
   b. Describe the purpose of cleaning and borax fluxing a silver brazing joint and the purpose of cleaning the joint after soldering.

4. Demonstrate the process of oxyacetylene cutting.
   a. Adjust and extinguish the cutting torch.
   b. Make the following cuts on mild steel: straight lines, 90° turns and holes.

5. Demonstrate the process of oxyacetylene brazing and welding.
    a. Adjust and extinguish the oxyacetylene welding torch.
    b. Weld beads on plate without filler rods.
    c. Weld beads on plate with filler rod.
    d. Weld joints in different positions with filler rod.
6. Demonstrate the process of bronze braze welding.
    a. Identify the principles of bronze brazing.
    b. Braze weld a square edge joint in any position.
7. Describe the principals of ARC welding.
    a. Identify and describe the parts and function of the electric arc welding unit.
    b. Identify and select electrodes properly.
    c. Set up, adjust and shut down the arc welding unit.
    d. Strike and maintain an arc.
8. Demonstrate arc welding procedures.
    a. Make a pad in the flat position.
    b. Make a pad in the horizontal position.
    c. Make a multiple pass T-joint fillet weld in the horizontal position.

## EE. SHEET METAL

1. Discuss the manufacturing processes, properties, and varieties of metals used in the sheet metal trades.
2. Demonstrate skill in using sheet metal hand tools.
    a. Demonstrate the proper use of measuring and marking tools.
    b. Demonstrate the proper use of bench tools.
    c. Demonstrate the proper use of sheet metal cutting tools.
    d. Demonstrate the proper use of joining tools.

3. Demonstrate proper procedure for joining sheet metals using fasteners, seams and joints.
   a. Basic fitting layout. Emphasis is placed on various types of seams, elbows and ducts.
4. Detail involved in fitting layout. Triangulation used in construction of various square and round fittings.
5. Emphasis is placed on short cuts in triangulation. Development of proper bench procedures needed in sheet metal layout.
6. Fitting-layout with emphasis on proper area for air distribution needed in air conditioning. Fitting and duct to first be designed by use of the trane ductalator.
7. Designing a ventilation system for a residential or small commercial installation. Emphasis will be placed on grill placement and proper duct sizing.
8. Demonstrate skills and proper procedures in using sheet metal machines (shears, bar boulder, slip and roll forming machines, hand brake, and box and pan brakes, and metal seaming machines.

FF. FUNDAMENTALS OF ELECTRICITY

1. List specific safety rules in the electricity area (fire, poison, electrocution).
   a. Define general safety rules in the electrical shop.
   b. Demonstrate first aid procedures for shock victims.
2. Explain the electron theory as it relates to electricity and distinguish between static and current electricity.
   a. Discuss how static electricity is used in the climate control trade (electrostatic air cleaners and refrigerator capacitors and condensors).

   b. Discuss the two kinds of current electricity and the electron movement involved (AC and DC), generators, alternators.

3. Describe the different measurements and terms associated with electrical power. Discuss transformer theory.
   a. Define voltage and the various types of voltage (applied or source voltage, voltage rating, voltage drop).
   b. Define the meaning of ampere.
   c. Define the meaning of ohm and the variables that affect resistance.
   d. Define the meaning of the coulomb.
   e. Define the meaning of the term watt and review watts law for DC power.
   f. Define the meaning of the term horsepower.
   g. Describe the various munerical prefixes (mili, micro, kilo, mega).

4. Describe the six methods of producing electricity, cite examples of each, and discuss the type of current produced (friction, heat, light, pressure, chemical action, mechanical motion).
   a. Define the basis of producing electricity with mechanical motion (conductor + magnetic field + movement = voltage).
   b. Describe the principles of producint electricity with heat and the operation of a thermocouple.
   c. Describe methods of producing mechanical motion - fossil, solar, nuclear, gravitational, geothermal.
   d. Perform experiments in production of electricity in some of the methods of producing electricity.

5. Identify and work problems using Ohms law to compute voltage, current, and resistance.
6. Describe the various materials and types of materials that will not transmit electricity (nonconductors), glass, rubber, plastic, wood, ceramic and mica).
7. Describe the various materials and types of materials used to transmit electricity (conductors).
    a. Define the four main materials for wire and the relative conductivity (silver, copper, gold and aluminum).
    b. Define the conductors of electricity (silver, coppper, gold, aluminum, tungsten, zinc, brass, platinum, iron, nickel, tin, steel, lead, mercury, nichrome).
    c. Define the pros and con s of solid wire vs. stranded wire and state the conditions of use for each of these types of wire.
    d. Define the various types of wire coverings and the advantages and disadvantages of each under certain conditions.
    e. Demonstrate the flow of electrons through various sizes of wire (gauge).
    f. Describe the principles, materials, and use of resistance wire and discuss resistance wire in electrical heating elements.
8. Define the various semiconductors of electricity and their place in solid state electronics.
9. Demonstrate the use of electrical resistors (semiconductors) in electronic circuits.
    a. Define the types and use of fixed resistors.
    b. Define the types and use of variable resistors (potentiometers, rheostats, and trimmer resistors).

   c. Compute resistor values and tolerances using a meter and color code.
   d. Demonstrate the types and uses of thermistors (negative coefficient type - NTC, and positive temperature coefficient type - PTC, used in temperature operated electric circuit control, to measure temperatures, and to stop electric power flow to a motor if the whindings temperature increases.

10. Define the purpose of capacitors used in the climate control trade.
11. Describe the purpose of other electrical components used in the climate control trades (diodes, rectifiers, transistors, sensors, amplifiers, transducers, transformers, etc.)

GG. ALTERNATING CURRENT FUNDAMENTALS

1. Describe and state the pros and cons of single phase current vs. three phase current.
2. Demonstrate and discuss the various characteristics of AC sine waves (frequency, period, negative and positive amplitude, RMS value), impedance, resistances.
3. Apply resistance sine waves to the various phase relationships.

HH. ELECTRIC MOTORS

1. Describe magnetism and its relationship to electric motors.
   a. Explain electromagnets and polarity in relation to current flow.
   b. Explain how an electromagnet supplies the magnetic field for motor rotation.
2. Demonstrate magnets in an induction type motor (stators and rotors).
3. Demonstrate the safety rules in working with electric motors.

4. Identify and discuss common types of motor mounts (cradle mount, blower frame mount, three ring mount, lug ring mount, rigid mount, pump mount).
5. Describe the advantages and disadvantages of various motor enclosures (open, open-drip proof, totally enclosed, explosion proof, submersible).
6. Identify and discuss the purpose of the major parts of an open drive motor (stator assembly, rotor, end bells, overload, centrifugal control, starting switch, assembly bolts).
7. Demonstrate the types of single phase motors and state the major use of each type (split phase, shaded pole, capacitor start induction run C.S.I.R., capacitor start capacitor run C.S.R., permanent split capacitor P.S.C.)
8. Define the purpose, construction and advantages of a three phase motor.
9. Describe the purpose and use of information given on the motor data plate.
10. Split phase motors.
    a. Demonstrate the common applications of split phase motors and the common horse power range of these motors (fans, oil burners, pumps, blowers, domestic refrigeration compressors, 1/20-3/4 HP, open drive and hermetic).
    b. Define the two types of windings on a split phase motor and the characteristics of these windings (start, run).
    c. Describe the components of a split phase motor and review the purpose of these components.
    d. Define the NEMA motor lead codes for start and run windings and the typical motor lead color codes.

   e. Describe motor wiring for the directions of rotation of a split phase motor.
   f. Wire a split phase dual voltage motor to a 208/240 VAC supply.
   g. Disassemble, inspect, clean, and reassemble a split phase motor.

11. Shaded pole motors
   a. Describe the common applications of shaded pole motors (refrigerator evaporator fans, refrigerator condenser fans, window air conditioner fans, furnace flowers, furnace combustion fans, timers).
   b. Describe the construction of the shaded pole stator.
   c. Define the disadvantages of using shaded pole motors and the most common remedy for motor failure.
   d. Demonstrate the relationship of the number of poles to the motor RPM in shaded pole motors.
   e. Define the voltages of shaded pole motors.
   f. Describe the mechanical and electrical methods of reversing the rotation of shaded pole motors.
   g. Demonstrate the methods of varying the speed of shaded pole motors.
   h. Perform a maintenance check on a shaded pole motor.

12. Capacitor motors
   a. Describe the characteristics and common applications of capacitor motors.
   b. Define the two types of capacitor motors (open drive, hermetic).
   c. Define the advantages of the C.S.I.R. motor.
   d. Define the advantages of the C.S.R. motor.
   e. Define the advantages of the P.S.C. motor.
   f. Demonstrate the wiring diagrams of the capacitor motors.

13. Three phase motors
    a. Define the difference and major advantages and disadvantages of the major types of three phase motors (synchronous, squirrel cagerotor, and wound rotor).
    b. Describe the electrical characteristics of three phase motors and their components.
    c. Define the differences between a delta wound motor and wye wound motor.
    d. Reverse the rotation of a three phase motor.
14. Describe common motor problems, the causes of the problems, and the remedy to solve the problems.
    a. Excessive noise.
    b. Failure to start.
    c. Overheating of motor.
    d. Overheating of bearings.
    e. Rotor of stator burned out.
15. Demonstrate the types of motor V-pulleys (sheaves) and the methods for determining the size of the pulleys (standard, step, adjustable).
16. Calculate the size belt needed to attach to two pulleys given the diameter of the pulleys and the distance the pulleys are apart OC.

II. ELECTRICAL CIRCUITS AND WIRING DIAGRAMS.

1. Define various symbols used to graphically represent various electrical components and devices.
2. Define the three basic areas all circuits have in common (source of power, conductor, and load).
3. Define the other two devices most circuits contain (circuit protective devices and circuit controlling devices.)

4. Circuit protective devices.
    a. Identify common types of overcurrent protective devices, explain their operation, and discuss the pros and cons of various applications (blade type cartridge fuse, ferrule type cartridge fuse, type S plug fuse, edison base plug fuse, circuit breaker, fusible link).
    b. Define the operation of a single element fuse.
    c. Define the operation of a time delay fuse.
    d. Define the operation of a circuit breaker.
    e. Define the national electric code requirements for fuses less than 600 volts.
    f. Define the national electric code requirements for circuit breakers that are less than 600 volts.
    g. Define pressure activated protection devices.
    h. Demonstrate the function and types of electrical system protection devices (bimetal overload, magnetic overload, thermal overload relay, lockout relay, solid state compressor motor protector).
    i. Install a lockout relay.
    j. Examine and test a solid state compressor motor protector.
5. Define the components and operation of the major circuit controlling devices - switches (3 and 4 way, rotary single, multiple position, push button-PBNO-PBNC, thermal types, pressure types, SPST, SPDT, DPST, DPDT, limit types, magnetic, photoelectric, proximity, etc.)
6. Define the basic design, electrical rules, and purpose of series circuits.
7. Define the basic design, electrical rules, and purpose of parallel circuits.

8. Define the basic design, electrical rules, and purpose of parallel circuits.
9. Compute series, parallel, and series parallel circuit electrical values.
10. Demonstrate pictorial and ladder schematic wiring diagrams and list the major characteristics of each type.
11. Define the common faults of electrical circuits (open circuits, closed circuits, and short circuits.)
12. Demonstrate the major steps in building and tracing a ladder schematic and trace the electrical current through several ladder schematics.
13. Demonstrate the ability to draw various pictorial and schematic wiring diagrams and ladder diagrams.

JJ. OTHER ELECTRICAL CONTROLS AND COMPONENTS

1. Demonstrate a working knowledge of the gas heating system. Define the safeties and controls involved in the system. Describe all tools and procedures used in proper diagnosing and repairing of the system.
    a. Types and history of gas combustion.
    b. Types of gas fired furnaces and burners--location of parts.
    c. Safeties used in residential gas fired equipment.
    d. Control systems used in residential gas fired equipment.
    e. Setting BTU input.
    f. Annual service.
    g. Problem diagnosis - electrical.
    h. Problem diagnosis - mechanical.
    i. Safeties in commercial burners.
    j. Problem diagnosis - commercial.

2. Describe the components, construction, wiring specifications and purpose of step up and step down transformers.
3. Identify the three types of termostats and their components and explain the pros and cons of each type (low voltage thermostats, milivolt thermostats, line voltage thermostats, aquastats, PTC's).
    - a. Describe the operation of a bimetal temperature sensing element, the various shapes of the bimetals, the function in opening and closing contacts (helix, cantilever, "U", spiral, snap disc).
    - b. Describe the difference between a snap action and mercury bulf thermostat contact, the function of each and the pros and cons of using these contacts.
    - c. Describe thermostat heat anticipators.
    - d. Describe the operation and advantages of a time controlled thermostat.
    - e. Determine heat anticipation of a thermostate and properly adjust the heat anticipator.
    - f. Demonstrate the digital stats and multi set back theory.
    - g. Install a wall thermostat.
4. Demonstrate and discuss the functions and specifications of different types of relays and their parts.
    - a. Demonstrate and explain the purpose and function of a contacter relay.
    - b. Demonstrate and discuss various motor starting relays (potential, coil type and hot wire type current relays, solid state relays).
    - c. Describe selection specifications of motor relays.
    - d. Demonstrate and explain the purpose of time delay relays.
    - e. Draw connecting wiring to various types of relays and a contactor.
    - f. Wire a hot wire and coil type current relay.

   - g. Wire a potential relay.
   - h. Wire a fan relay.
   - i. Check wiring and various relays with electrical test instruments (ohmeter, voltmeter, ammeter).

5. Demonstrate understanding of the electromagnetic operation of a solenoid valve and the two types of solenoids (push type, pull type).

6. Demonstrate and discuss the types of capacitors and the role of capacitors in the operation of motors (run capacitor and start capacitor).
   - a. Describe use of solt start components vs. hard start.
   - b. Determine the sizes of various capacitors.
   - c. Calculate the capacitance of capacitors wired in series and parallel.
   - d. Define the factors to consider when replacing capacitors.
   - e. Define the major causes of capacitor failure (discuss type of oil used in run capacitor).
   - f. Wire a run capacitor with a P.S.C. compressor motor.
   - g. Wire a run capacitor with a C.S.R. compressor motor.

KK. OIL HEATING

1. Demonstrate a thorough understanding of the oil heating system. Describe all the controls and safeties in detail. Define proper procedures used in diagnosing and correcting the service problems.
   - a. Types of burners.
   - b. Determining B.P.H. rate - nozzles.
   - c. Automatic oil burner controls.
   - d. Oil burner wiring.
   - e. Servicing primary and CAB cell controls.

- f. Annual service required.
- g. Adjusting combustion efficiency.
- h. Ignition and pump problems.
- i. Basic burner service methods.
- j. Combustion problems - pulsations.

LL. ELECTRICAL TEST METERS

1. Demonstrate the safety precautions when taking various electrical measurements.
2. Demonstrate the proper procedure when probling circuits to take test readings.
3. Demonstrate the ability to read dial type meters including digitals.
4. Demonstrate the ability to take electrical measurements with volt meters, amp probes, ohm meters, watt meters, and VOM's.

MM. ELECTRIC HEATING

1. Demonstrate a working knowledge of the operation and service involved in the electric heating system.
    - a. Describe different types of electric heating with emphasis on efficiency.
    - b. Describe theory of operation of electric furnaces.
    - c. Demonstrate installation and servicing problems encountered with electric furnaces.
    - d. Define heat pumps, their advantages, disadvantages and operating characteristics.
    - e. Define reversing valves and defrost mechanisms used in heat pumps.
    - f. Describe trouble shooting heat pumps and related control systems.
    - g. Describe electric boilers, their advantages and limitations.

   h. Demonstrate analysis of electric hydronic systems and accessories.
   i. Define troubleshooting electric hydronic controls and contol systems.
   j. Define problems encountered with radiant panel electric heating and line voltage thermostats.

NN. HEAT PUMPS

1. Demonstrate installation of both air to air heat pumps and air to water heat pumps.
   a. Read prints, diagrams, and manufacturers installation specifications.
   b. Mount packaged and split systems based on space requirements, mounting methods, and adequate supply of water, the specified air flow, ventilation, accessability, drain facilities, duct layout, piping layout, installation codes.
   c. Connect electric motors, heating coils and controls based upon electrical codes and power, voltage and phase requirements.
   d. Make the pipe connections including couplings and fittings to the following: Line, water, refrigerant, drain and defrost.
   e. Perform the necessary mechanical and electrical checks, tests, and measurements.
   f. Purge, charge and test the system.
   g. Start up and test the completed system and adjust for efficiency.

OO. HYDRONIC HEATING AND COOLING

1. Describe proper sizing of hydronic heating system - selection of baseboard pumps and proper controls. Describe the proper information to install and service hydronic heating systems.
   a. Define theory of calculating heat gains.
   b. Calculation of heat gain on project house.

c. Describe boilers, boiler ratings, sizing and piping arrangements.

d. Define ratings of heat distributing units, location and sizing procedures.

e. Demonstrate air cushion tanks and air elimination devices.

f. Demonstrate piping layouts and practices.

g. Develop design water temperatures and pumps.

h. Define zoning methods and pipe sizing.

i. Demonstrate design of complete system for project house.

j. Describe residential steam heating systems.

PP. DUCT DESIGN

1. Demonstrate design of ductwork used in air conditioning systems. Describe heat loss, duct sizing and register location and air circulation.

a. Demonstrate typical building construction and blueprints.

b. Define comfort, how the human body loses heat, importance of good design of heating and air conditioning systems, basics of heat flow through building walls, windows, ceilings, and floors.

c. Describe infiltration and how to calculate it.

d. Work heat loss calculation work sheet, solar, latent, and internal heat gains preparing for cooling load calculation procedure.

e. Comparative fuel costs and good venting methods.

f. Describe history of warm air heating, 40 years of industry-sponsored research investigations at University of Illinois leading to development of design procedures.

g. Demonstrate air flow patterns in ducts and measurement of pressures and resistances to air flow.

h. Describe types of fans and fan performance. Demonstrate equal friction method of duct sizing.

i. Demonstrate the selection of good fittings; methods of installation; principles of continuous air circulation.

QQ. AIR DISTRIBUTION

1. Describe various problems that can arise from a system that is not properly balanced. Demonstrate various methods of air balancing.

a. Define basic concepts fluids vs pressure (air).

b. Demonstrate measurement of pressure instruments and their use in balancing.

c. Describe air flow through ducts. Velocity changes due to design.

d. Define horsepower vs. C.F.M

e. Define laws governing fans.

f. Demonstrate selecting the proper fan for the job.

g. Describe balancing the proper relationship between fan and duct size.

h. Define cost saving with proper balancing.

i. Demonstrate adjustments made during balancing.

RR. BASIC REFRIGERATION KNOWLEDBE NEEDED

1. Describe the terms used in Air Conditioning and Refrigeration industry. Define pressure and temperature as it pertains to boiling liquids. Describe air treatment needed for various comfort conditions. Psychometrics.

a. Describe the basic parts in the refrigeration cycle.

b. Describe basic terminology used in refrigeration.

  - c. Define temperature, latent heat and pressure.
  - d. Define enthalpy and its use, heat transfer.
  - e. Demonstrate steam tables.
  - f. Describe body comfort.
  - g. Demonstrate body comfort - psychometrics.
  - h. Describe psychometrics.
  - i. Demonstrate psychometrics and basic load estimation.
  - j. Describe load estimation.

2. Demonstrate a working knowledge of the reciprocating compressor and all other components involved in the refrigeration system. Define each of the four major components involved in the system and how they affeet the overall efficiency of the system.
   - a. Demonstrate mechanical refrigeration cycle.
   - b. Define properties of refrigerant.
   - c. Describe gas laws.
   - d. Define pressure - enthalpy relationships.
   - e. Describe unit capacity and refrigeration effect.
   - f. Define efficiencies of the compressor.
   - g. Demonstrate effect of subcooling and superheating refrigerants.
   - h. Define power requirements of compressors.
   - i. Describe lubrication and valves.
   - j. Demonstrate compressor unloaders.
   - k. Demonstrate metering devices.
   - l. Demonstrate proper line sizing techniques
   - m. Demonstrate general problem solving techniques.
3. Describe various types of systems used in residential and commercial air conditioning and refrigeration. Define air distribution fan theory and total comfort. (Human or product).

a. Describe centifugal refrigeration system.

b. Describe control of centrifugal.

c. Describe capacity control methods.

d. Describe absorption system.

e. Describe heat pump - systems.

f. Define source of heat.

g. Demonstrate use of solar energy.

h. Describe air wash units.

i. Describe fan theory.

j. Define air pressure in ducts.

k. Demonstrate fan efficiency and design.

SS. AIR CONDITIONING AND REFRIGERATION - ELECTRICAL

1. Describe application of basic electricity as it applies to the servicing and installation of heating, air conditioning and refrigeration equipment.

a. Demonstrate understanding of electron theory, DC current flow, conductors and insulators, voltage and resistance.

b. Demonstrate Ohms Law, resistance in series and parellel circuits and power.

c. Demonstrate magnetism, magnetic fields, generator principles, transformers, switches and relays.

d. Define inductance, impedance and capacitance.

e. Describe electric motors.

f. Demonstrate measuring instruments, schematic symbols and circuits.

g. Define temperature and pressure sensing controls.

h. Define fundamental heating control circuits.

i. Define fundamental cooling control circuits.

j. Define fundamental refrigeration control circuits.

2. Basic Control Systems - Demonstrate principles of electric controls used in air conditioning and refrigeration. Demonstrate motor starting and safety contols. Demonstrate installation and service techniques.
   a. Define domestic refrigeration principles of control and sequence of operation.
   b. Describe refrigeration motor controls, thermostats, pressure switches and timers.
   c. Demonstrate motor starting techniques; hot wire relays, current relays, potential relays and centrifugal switches.
   d. Describe defrost controls used in domestic refrigeration.
   e. Describe domestic ice maker circuits and controls.
   f. Describe commercial systems control principles and sequence of operation.
   g. Describe commercial compressor motor starting systems, both single and three phase.
   h. Describe humidification and dehumidification controls.
   i. Describe window air conditioning system controls; thermostats, overloads and motor starting controls.
   j. Describe window heat pump controls and sequence of operation.
3. Advanced electrical control systems. Demonstrate proper selection of controls and their placement in the electrical circuit.
   a. Describe thermostats: theory of operation, circuitry, installation, calibration and trouble shooting.
   b. Describe transformers: sizing, wiring and troubleshooting.
   c. Describe contactors, motor starters and overload protection, theory of operation, application and troubleshooting.

d. Demonstrate evaporator blower controls, single and multiple speed, problems encountered in relation to accessories.

e. Demonstrate heat pump reversing valves and liquid solenoid valves, theory of operation and troubleshooting.

f. Demonstrate pressure switches, defrost solenoids and timers.

g. Define methods of low ambient control.

h. Demonstrate by combining above controls into systems.

4. Advanced control systems. Demonstrate working knowledge of electrical and pneumatic control systems used in commercial building.

a. Describe modulating control circuit application.

b. Describe modulating control circuit operation.

c. Demonstrate modulating controllers: room thermostats, remote bulf temperature controllers and pressure controllers.

d. Demonstrate modulating motors: reversible capacitor motor, balancing relay, feedback potentiometer and gear train.

e. Demonstrate installation and troubleshooting procedures.

f. Demonstrate valves, dampers and linkages, installation and adjustment.

g. Describe pneumatic control systems; system operation, measured variable, controlled variable, control agent and controlled devices.

h. Describe controllers; controller feedback, measuring element, supply pressure.

i. Describe control modes; two-position, proportional and proportional plus reset.

j. Demonstrate applications of pneumatic controls.

## TT. AIR CONDITIONING AND REFRIGERATION SERVICE PROCEDURES

1. Demonstrate techniques required in the use of instruments, meters, gauges, and soldering equipment used in the installation and service of various systems.
    a. Demonstrate soldering equipment uses.
    b. Demonstrate soldering procedures.
    c. Demonstrate types of solder used.
    d. Demonstrate pressures - absolute and atmospheric - gauges.
    e. Demonstrate evacuation of the refrigeration system.
    f. Demonstrate charging of the refrigeration system.
    g. Demonstrate electrical meter use.
    h. Demonstrate checking electrical circuits.
    i. Demonstrate leak testing the refrigeration system.
    j. Demonstrate adding refrigerant charges.
2. Describe basic problems that arise in residential air conditioning systems. Demonstrate the proper use of meter and gauges used in diagnosing these problems and the procedures used in correcting them.
    a. Describe compressor function and problems arising with it. Valves and lubrication.
    b. Describe coil evap. and cond. coils problems and functions. Use of gauges and charging of equipment.
    c. Describe metering devices.
    d. Demonstrate PH charts. Plot heating condition.
    e. Describe commercial walk in. Pressure control. Settings for freezer and refrigeration.
    f. Describe domestic refrigerators and window shakers - how they differ from domestic central units.
3. Demonstrate a working knowledge of commercial refrigeration both from

an installation and service standpoint. Describe walk in freezers, reach in freezers and store coolers--also types of temperature control and methods of defrosting.

a. Describe types and uses of commercial equipment.

b. Demonstrate load calculations and equipment selection of commercial comfort equipment.

c. Demonstrate control devices used in commercial equipment.

d. Describe selection of proper system to meet the needs of the commercial job (human comfort).

e. Describe freezer construction and design.

f. Demonstrate sizing a freezer for a given application.

g. Demonstrate proper component selection for freezer application.

h. Describe electrical controls used in commercial applications (product).

UU. CONSTRUCTION TRADES

1. Demonstrate the proper use and selection of carpentry and building trade hand and power tools.

2. Demonstrate knowledge of properties, handling procedures, and fabrication techniques of common building materials (wood, concrete, metals, insulation).

3. Demonstrate an understanding and comprehension of various local, state and national building codes for the following areas: structural codes, electrical codes, fluid component codes, insulation codes, heat exchanger codes, and residential energy codes.

4. Describe the purpose, functions and construction methods involved in building residential and commercial buildings.

   a. Describe the materials and construction techniques in foundations.

b. Describe the materials and construction techniques of walls.

c. Describe the materials, styles, and construction techniques of residential and commercial roofs.

Objectives (con't)

The second objective was to research solar industry to determine employment opportunities. This was already done by Southern Illinois University in their "Development of a Training Program for Installation of Solar Energy Systems in Residential Buildings." These employment opportunities were noted and discussed by our advisory board along with checking the Illinois Solar Energy Directory and the National Solar Energy Educational Directory supportive material. It was felt that persons must be made available to install and service before the solar industry can be viable.

## TABLE I

## SOLAR ENERGY BUILDING AND DESIGN PROFESSIONALS IN DUPAGE COUNTY

| COMPANY | FUNCTION |
|---|---|
| CENTURY SOLAR CONDITIONING SYSTEMS<br>716 W. IRVING PARK ROAD<br>BENSENVILLE, ILLINOIS 60106<br>(312) 860-2555<br>RICK ROYEM | CONSULTING ENGINEERING |
| MICHAEL L. IVES AND ASSOC.<br>15 SPINNING WHEEL ROAD<br>SUITE #20<br>HINDSDALE, ILLINOIS 60521<br>(312) 887-0860 - 887-0864<br>MICHAEL L. IVES, PRESIDENT<br>JOHN M. RYAN, VICE PRESIDENT | LANDSCAPE ARCHITECTURE |
| GEORGE C. OLSON ARCHITECT<br>43 E. JEFFERSON<br>NAPERVILLE, ILLINOIS 60540<br>(312) 420-1400<br>VERN MOLBURG | ARCHITECTURE<br>MECHANICAL ENGINEERING<br>HVAC ENGINEERING<br>GENERAL CONTRACTING<br>ENVIRONMENTAL DESIGN |
| PACKER ENGINEERING<br>N. WASHINGTON ST. AT E-W TOLLWAY<br>NAPERVILLE, ILLINOIS 60540<br>(312) 355-5722 - 393-1608<br>CHARLES C. ROBERS, MGR. THERMAL SYSTEM | MECHANICAL ENGINEERING<br>BUILDING DESIGN |
| WIGHT AND COMPANY INC.<br>814 OGDEN AVENUE<br>DOWNERS GROVE, ILLINOIS 60515<br>(312) 969-7000<br>DONNA M. FLOERCHINGER | ARCHITECTURE |
| WOODS AND ACCOC. INC.<br>112 WATER STREET<br>NAPERVILLE, ILLINOIS 60540<br>(312) 355-2360<br>KENNETH R. WOODS, PRESIDENT | ARCHITECTURE<br>STRUCTURAL ENGINEERING<br>ELECTRICAL ENGINEERING |

## TABLE II

## DISTRIBUTORS OF SOLAR EQUIPMENT IN DUPAGE COUNTY

| COMPANY | PRODUCT LINES CARRIED |
|---|---|
| G. W. BERKHEINER<br>25 W. NORTH AVENUE<br>VILLA PARK, ILLINOIS 60181<br>(312) 832-8885 | LIBBEY-OWENS-FORD CO./<br>SOLAR ENERGY SYSTEMS<br>TOLEDO, OHIO |
| CENTURY SOLAR CONDITIONING SYSTEMS<br>716 W. IRVING PARK ROAD<br>BENSENVILL, ILLINOIS 60106<br>(312) 860-2555 | AMERICAN SOLAR KING CORP.<br>WACO, TEXAS |
| CLIMATE CONTROL CORPORATION<br>430 WRIGHTWOOD AVENUE<br>ELMHURST, ILLINOIS 60126<br>(312) 832-7676 | ARKLA INDUSTRIES INC.<br>EVANSTON, ILLINOIS |
| DUPAGE SOLAR SYSTEMS<br>2636 W. LUZERNE COURT<br>WOODRIDGE, ILLINOIS 60515<br>(312) 898-3892 | SOLAR SYSTEMS<br>NOVATO, CALIFORNIA<br>GEM MFG. CORP. SOLAR USAGE NOW<br>BASCOM, OHIO |
| ESP ASSOCIATES LTD.<br>1107 S. MANNHEIM<br>WESTCHESTER, ILLINOIS 60153<br>(312) 343-2882 | SOLARON CORPORATION<br>DENVER, COLORADO |
| H. P. WHELPLEY<br>1108 SWEETHAY COURT<br>P.O. BOX #88<br>NAPERVILL, ILLINOIS 60540<br>(312) 355-6661 | RESEARCH PRODUCTS CORP.<br>MADISON, WISCONSIN |

## TABLE III

## MANUFACTURERS OF SOLAR EQUIPMENT IN DUPAGE COUNTY

| COMPANY | EQUIPMENT |
|---|---|
| ETA ENGINEERING INC.<br>415 EAST PLAZA DRIVE<br>WESTMONT, ILLINOIS 60559<br>(312) 323-4663 | EVAPORATIVE COOLING APPLICATIONS |
| JOHNSON CONTROLS INC./PENN DIVISION<br>2221 CAMDEN COURT<br>OAK BROOK, ILLINOIS 60521<br>(312) 654-4900 | SOLAR CONTROLS - COMPLETE SYSTEMS |

Objectives (con't)

The third objective was to determine and develop career ladder systems and criteria for promotion.

These were approved by our advisory board as follows:

Ladder of Career Levels

1. Entry Level - novice, student beginning, apprentice, helper, stock person, laborer
2. Infield Learning Level - second-year student, third-year apprentice, third-year laborer, counter sales, component person (one who deals with specific products only.)
3. Semi-Skilled Level - certification degree-bearing student, fourth-year apprentice, in-house sales.
4. Skilled Level - certificate or degree-bearing student with tow years of field experience (total 4 years), journey person (fifth year in field), outside sales, technician.
5. Specialist Level - on-site sales, on-site sizing, equipment and system design person, technical service, troubleshooting person.
6. Supervisory Level - foreperson, lead person, customer service and sales representative (in-house level), inventory control person (computer), assistant manager.
7. Management Level - owner of HVACS shop, contractor or subcontractor, business manager, sales manager, territorial manager of service manager, parent company, main management, board member.

The Entry Level positions in HVACS field are considered to be set at a point where anyone with basic mathematical, scientific, drafting, construction, and mechanical aptitude could enter the field and advance beyond through training and experience.

The Infield Learning Level positions should be an integrated educational and practical experience for the individual. The person at this point should be in direct contact with persons in the more advanced levels. In order for a person to be promoted to Semi-Skilled, he or she must meet the following criteria:

1. Define basic HVACS terminology and describe theory of operation.
2. Demonstrate basic technical skill. (Work with hand-tools, motor capabilities, etc.)
3. Demonstrate ability to work with people.
4. Demonstrate ability to follow directions.
5. Demonstrate a willingness to advance to next level. (Some people enjoy being level-one personnel--"common laborer".)

The Semi-Skilled Level should be a very short period in the career flow-pattern. This is a final polishing and coordinating of all educational and practical experiences. In order for a person to advance from this level to skilled level, the following must be demonstrated:

1. Demonstrate ability to apply theory.
2. Demonstrate problem-solving capabilities.
3. Demonstrate ability to sell people using their knowledge and understanding of components used in the field.
4. Demonstrate ability to perform more complicated tasks without excessive supervision.
5. Successful completion of higher-level technical training.
6. Demonstrate specified duration and desire to move to next step.

The Skilled Level is equivalent in salary to an upper-middle-class income level. A person reaching this level may remain and exist quite comfortably. Anyone wishing to advance from this level must show definite drives in the following directions.

1. Demonstrate understanding of all HVACS (Heating, Ventilating, Air Conditioning, and Solar Systems.)
2. Demonstrate ability to diagnose electrical, piping, equipment problems.
3. Demonstrate ability to satisfactorily complete a task without any supervision.
4. Demonstrate desire to take charge and move into next level.

The Specialist Level is where a person who has shown exceptional skill in a particular area, plus understanding of all other levels, can receive additional monitary and mental satisfaction for his or her expertise. Advancement from this level to Supervisory Level can be achieved by the following:

1. Demonstrate ability to analyze difficult situations critically.
2. Demonstrate ability in specific technical skills and expertise beyond Skilled Level.
3. Demonstrate, through duration of years in field and continued education, a desire to develop specific high-level skills.

Supervisory-Level personnel are persons who no longer should be required to do the mechanics of the jobs. Instead, they should be capable of directing others from aforementioned levels to perform the job tasks. This position is approximately 50 per cent paper work and 50 per cent work-relation directionals. Anyone wishing to advance to Management Levels should be capable of achieving the following:

1. Demonstrate the ability to manage time and materials.
2. Demonstrate the ability to organize and control workflow of self and others.
3. Demonstrate the ability to communicate efficiently and effectively.
4. Demonstrate the ability to compensate for varying levels of stress on oneself.
5. Willingness to acquire position over others.

Management Level positions vary considerably. Advancement in Management Level positions is normally done through retirement or demise of Upper-Level Management persons. Years of expertise and sheer endurance may or may not cause an upper-level move. At this level, monitary compensations normally don't vary excessively from position to position. It has been determined that advancement is more politically-motivated in Management Level structure.

1. Demonstrate ability to integrate with upper-management personnel and make definite political contact as far as direction of management.
2. Demonstrate ability to sacrifice the use of scapegoat and take full responsibility for major decisions.
3. Demonstrate ability to manage.(If going into ownership, financial and business capability should be severely scrutinized before any decisions are made.)

# SOLAR INSTALLER CAREER LEVELS

OWNER, CONTRACTOR, MANAGEMENT

6 FOREPERSON, LEAD PERSON, SUPERVISOR

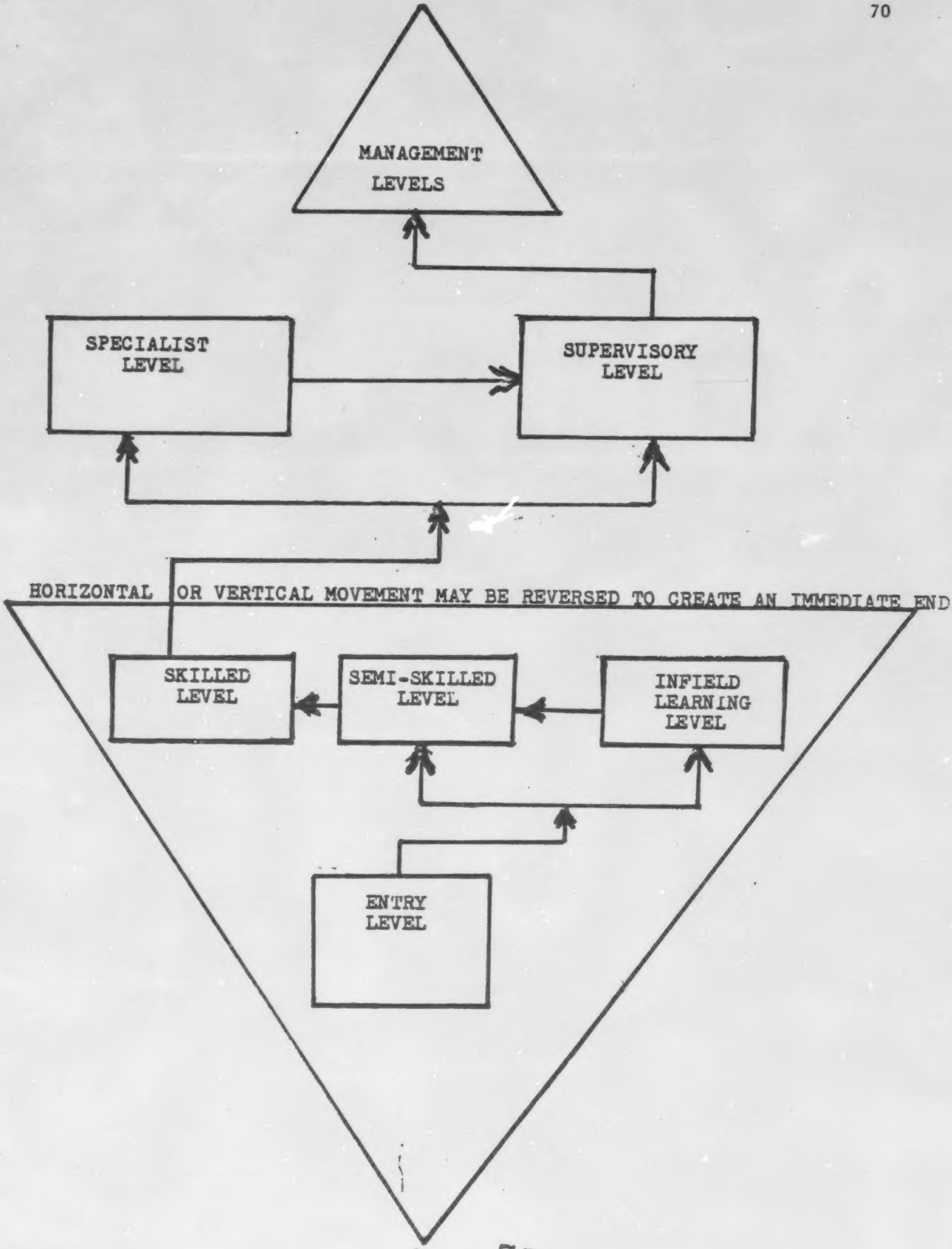
5 TECHNICAL SERVICE PERSON, ON SITE SALES, SPECIALIST

4 JOURNEY PERSON, GRADUATE STUDENT, SKILL AND EXPERIENCE

3 ADVANCED APPRENTICE, 2 YEAR DEGREE, SEMI SKILLED

2 COMPONENT PERSON, DEGREE SEEKING, APPRENTICE, IN-FIELD LEARNING

1 BEGINNING STUDENT-HELPER-LABORER ENTRY


MANAGEMENT LEVELS
SPECIALIST LEVEL
SUPERVISORY LEVEL
HORIZONTAL OR VERTICAL MOVEMENT MAY BE REVERSED TO CREATE AN IMMEDIATE END.
SKILLED LEVEL
SEMI-SKILLED LEVEL
INFIELD LEARNING LEVEL
ENTRY LEVEL

## Objectives (con't)

Objective 4 was to work with Instructional Design to develop measurable objectives for competency-based solar energy installer curriculums. This was done, but without much help from the Director of Instructional Design. The same is true of the development of teaching and evaluation strategies for each objective. The basis for the development of Objectives and Teaching and Evaluation Strategies was the existing materials used for over 12 years in the College of DuPage's HVAC Program..

Objective 5 was the Literature Search which was done by the Learning Resources Center along with materials accumulated over the past five years by the Director of the Project.

## INSTRUCTIONAL RESOURCES

| | |
|---|---|
| Slide Set | Kai Dib Films International<br>Richard L. Crowther,AIA, Solar Group Architects<br>*Sun Earth*: Solar Architecture |
| Text & Slides (also available) | *Solar Energy and Heating Systems*<br>P. O. Box 261<br>Glendale, California (1977) |
| Slide Set and Trainers | Lennox Industrial Inc. - Lennox<br>Phase I (SA) Solar Application<br>Lennox Educational Products (Iowa-Texas)<br>1600 E. Linn<br>Marshalltown, Iowa 50158 (1978) |
| (Other educational trainers) | RT-5, EB5, ST-17, AP-3 |
| Trainer System (total) | Suncell Solar Heating System<br>Research Products Corporation<br>Madison, Wisconsin 53701 (1977) |
| Texts | *Sun Earth: How to Apply Free Energy Sources to Our Homes and Buildings*<br>Crowther/Solar Group<br>310 Steele Street<br>Denver, Colorado 80206 (1977) |

Texts (con't)

The Solar Decision Book: A Guide for Heating Your Home with Solar Energy, by Richard H. Montgomery (John Wiley & Sons, New York. 1978)

Fundamentals of Solar Heating (Correspondence Course)
U. S. Department of Energy
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161 (1978)

Heating and Air Conditioning Systems Installation Standards for One and Two-Family Dwellings and Multi-Family Housing, Including Solar, by Better Heating and Cooling Bureau
(1977) SMACNA

Illinois Solar Energy Directory- Illinois' Alternative Energy Program.
Green and Pogany
325 West Adams Street, Room 300
Springfield, Illinois 62706 (1978)

National Solar Energy Education Directory
Solar Energy Research Institute
1536 Cole Blvd.
Golden, Colorado 80401 (1979)

Solar Energy Systems - Liquid, Air, Storage Systems
Solaron Corporation
440 Gallerig Tower
720 S. Colorado Blvd.
Denver Colorado 80222
(Application Engineering Manuals, Installation Manuals, Owners Manuals, and Design Manuals.)

Job-Related Training - Solar
Lennox Air Conditioning and Heating Inc.
Lennox Education Products
1600 E. Linn,
Marshalltown, Iowa 50158 (1978)

Model Document for Code Officials on Solar Heating and Cooling of Buildings (1979)
U. S. Depart of Energy
Cont. #EM-78-C-01-4281

Solar Energy - Progress and Promises
Council on Environmental Quality (1978)
Superintendent of Documents
Washington D. C. 20402
Stock #041-011-0036-0

Solar Energy in America's Future
Division of Solar Energy
Energy Research and Development Administration
Washington, D. C. (1977)
Stock #060-000-00078-6

Texts (con't)

*Solar Energy Information and Data for Illinois*, by Changnohs
Illinois State Water Survey (1978)
Cir. No.133 - (12-78-1500)

*Solar Energy Handbook - Theory and Application*
Power Systems Group AMETEK Inc.
Chilton Book Company/Radnor, Pennsylvania (1979)
Library of Congress Card No. 78-14646

*Proceedings of Solar Energy Storage Options*, Vols 1 & 2
March, 1979, San Antonia, Texas
National Technical Information Service
U. S. Department of Commerce
Springfield, Virginia 22161
Cont. 790328-P1
Final Report H-C0199-79-753F (1979)

*Suncell Solar Heating Systems*
Research Products Corporation (Solar Division)
Madison, Wisconsin
and
*Solar Energy in Industrial Process Heating*
Installation Manuals, DHW & Total House

*Installation Guidelines for Solar DHW Systems in One and Two-Family Dwellings*, by Franklin Research Center
Philadelphia, Pennsylvania
Superintendent of Documents
U. S. Government Printing Office
Washington, D. C. 20402
Contract #H-2377

*Revere Sun-Pride System*
Revere Solar and Architectural Products, Inc.
Rome New York 13440
Installation Manual - DHW & Total House

*Design Manual for Solar Heating of Buildings and Domestic Hot Water*, by Field.
Sol Pub Co.
P. O. Box 9209
College Station, Texas 77840 (1977)
Publication 501

*Design Criteria for Solar Heated Buildings*
Sunworks Technical Publication (1975)
Sunworks, Inc., Guilford, CT 06437

*Energy and Solar Heating*, by Bason
An Issue-Oriented Module Coordinated by AA of PT (1977)
Michigan State University

Texts (con't)

DOE Facilities Solar Design Handbook (1978)
U.S. Dept. of Energy DOE/AD-0006/1
National Technical Information Service
U.S. Dept. of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Stock #061-000-00097-6

Solar Energy in Buildings - For Engineering, Architecture, and Construction
John Wiley & Sons, New York (1979)

Here Comes the Sun - A Manual Explaining Practical Solar Heat Applications with Blueprints for Solar Systems Using Air and Water, by Xoxon
Jordan College, Michigan. (1977)

Energy Saving Conservationist Solar Systems
A. O. Smith Corp.
Consumer Products Division -Solar Catalog (1978)
Kankakee, IL
7250 S. Cicero Avenue
Chicago, IL 60629

Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings (1976)
Energy Research and Development Administration
Division of Solar Energy
Washington, D. C. 20543
NBSIR 76-1187

SEM - 79
Solar Engineering Master Catalog - Solar Industry Index
Solar Energy Industries Association
Solar Engineering Publishers Inc.
8435 N. Stemmons Freeway
Dallas, Texas 75247

Magazines and Newspapers

Solar Products Specifications Guide
Solar Age Magazine
P. O. Box 4934
Manchester, N. H. 03108

Solar Age
P. O. Box 4934
Manchester, N. H. 03108

Solar Times
3011 Post Road
Madison Ct. 06443

SERI - Solar Energy Research Institute
1617 Cole Blvd.
Golden Colorado 80401

Objectives (con't)

In the original proposal the sixth objective was identified as field testing the curriculum guide. This objective will be accomplished during Phase II of the project which is being funded under grant agreement No. R-33-21-X-0542-316. Pages 76 through 95 indicate the work that has been accomplished to initiate the field-testing phase.

COLLEGE OF DuPAGE ♻ GLEN ELLYN ILLINOIS 60137 ♻ TELEPHONE 312-858-2800

TO: Illinois Instructors of Heating, Air Conditioning, Refrigeration, Solar

FROM: Gene C. Walker, Coordinator of Heating, Ventilating, Air Conditioning, Refrigeration, Solar Curriculum, College of DuPage

RE: Competency Based Solar Installers Curriculum Guide

In cooperation with the Illinois State Board of Education, Department of Adult Vocational Technical Education, I am currently involved in developing Competency Based Curriculum Guides in the area of installation of active solar systems. Each competency identified by the industry will be provided with suggested learning activities, evaluation strategies, and references. This will also include back-up systems and be geared toward retrofit of existing structures. In order to make these materials viable and determine their usefulness to instructors, I would appreciate your reviewing and evaluation of this curriculum guide.

Knowing how busy your schedule is, and how much in advance you must plan your program for the following year, I would like to request of you at this time to consider instituting one or several of the solar courses that I am developing into your fall program. This would be used as a field test to get direct student feedback on the curriculum.

If you would like to assist in reviewing sections of the guide and/or field test some of the units, please complete the enclosed information form and return it in the enclosed self-addressed envelop.

If you have any questions, please feel free to contact:

Gene C. Walker
Technology Division
College of DuPage
Glen Ellyn, Illinois 60137

Telephone:

(312) 858-2800, ext. 2088 or 2322

GCW:pp

Enc.

Your name ______________________________________________

Title ______________________________________________

School Name ______________________________________________

Address ______________________________________________
Street City Zip

Telephone: ______________________________________________
Area Code

Number of classes now taught in Solar or HVAC field ____________

Quarter ____________ or Semester system ____________

Number of students enrolled in your area in 1979-80 school year: ________

Degree program ____________ or Certificate ____________

I would like to field test a section of the solar curriculum guide:

____yes ____no Stipend will be offered.

I would like to assist in reviewing sections of the guide:

____yes ____no

I would like to recieve a guide when it is completed:

____yes ____no

Thank you for your help.

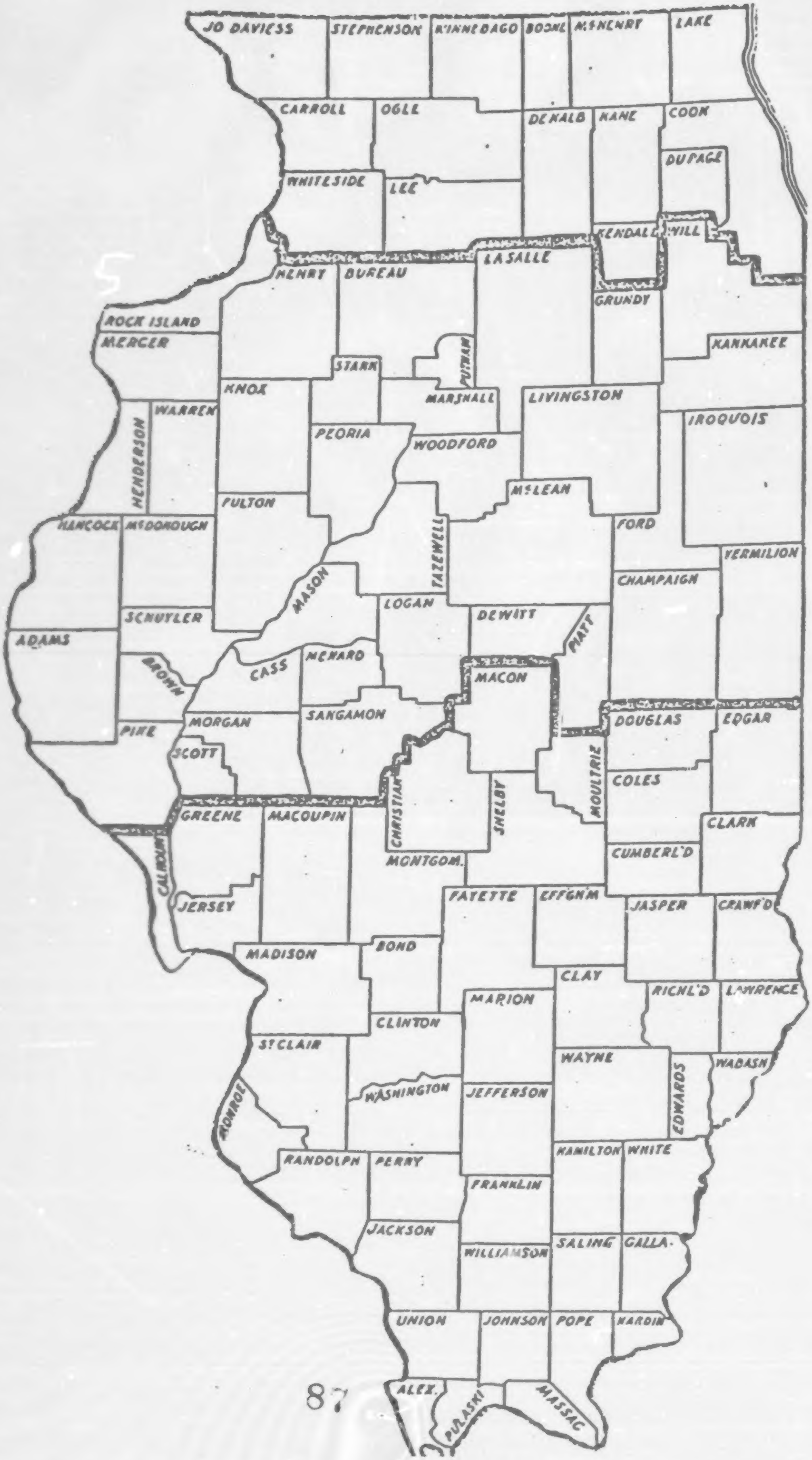
Gene C. Walker

Gene C. Walker

**Region One**

**Region Two**

**Region Three**


JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
McHENRY
LAKE
CARROLL
OGLE
DEKALB
KANE
COOK
DUPAGE
WHITESIDE
LEE
KENDALL
WILL
LASALLE
HENRY
BUREAU
ROCK ISLAND
MERCER
GRUNDY
KANKAKEE
STARK
PUTNAM
KNOX
MARSHALL
LIVINGSTON
WARREN
HENDERSON
PEORIA
WOODFORD
IROQUOIS
McLEAN
FULTON
HANCOCK
McDONOUGH
TAZEWELL
FORD
VERMILION
MASON
CHAMPAIGN
SCHUYLER
LOGAN
DEWITT
PIATT
ADAMS
BROWN
CASS
MENARD
MACON
MORGAN
SANGAMON
PIKE
SCOTT
DOUGLAS
EDGAR
COLES
MOULTRIE
SHELBY
CHRISTIAN
GREENE
MACOUPIN
CALHOUN
MONTGOM.
CLARK
CUMBERL'D
FAYETTE
EFFGH'M
JASPER
CRAWF'D
JERSEY
MADISON
BOND
CLAY
RICHL'D
LAWRENCE
MARION
CLINTON
ST CLAIR
WAYNE
WABASH
MONROE
WASHINGTON
JEFFERSON
EDWARDS
HAMILTON
WHITE
RANDOLPH
PERRY
FRANKLIN
JACKSON
WILLIAMSON
SALINE
GALLA.
UNION
JOHNSON
POPE
HARDIN
ALEX.
PULASKI
MASSAC
5

Your name Dr. Charles Warthen

Title Dean of INSTUCTION

School Name Black Hawk College - East Campus

Address Box 489 Kewanee Il. 61443
Street City Zip

Telephone: 309 - 852 - 5671
Area Code

Number of classes now taught in Solar or HVAC field 0

Quarter ____________ or Semester system ____________

Number of students enrolled in your area in 1979-80 school year: 0

Degree program ____________ or Certificate ____________

I would like to field test a section of the solar curriculum guide:

[✓ yes] ____ no

I would like to assist in reviewing sections of the guide:

[✓ yes] ____ no

I would like to recieve a guide when it is completed:

[✓ yes] ____ no

Thank you for your help.

Gene C. Walker

Your name ERNEST HARFST

Title CHAIRMAN, IND TECH DIV

School Name KISHWAUKEE COLLEGE

Address ______ MALTA IL 60150
Street City Zip

Telephone: 815 825 2086 #295
Area Code

Number of classes now taught in Solar or HVAC field ——

Quarter ________ or Semester system ✓

Number of students enrolled in your area in 1979-80 school year: 200

Degree program 150 or Certificate 50

I would like to field test a section of the solar curriculum guide:

✓ yes ____ no

I would like to assist in reviewing sections of the guide:

✓ yes ____ no

I would like to recieve a guide when it is completed:

✓ yes ____ no

Thank you for your help.

Gene C. Walker

Your name Ronald H Hoppach

Title Associate Professor

School Name Sauk Valley College

Address R5- Dixon Illinois 61021
Street City Zip

Telephone: 815 288 5511
Area Code

Number of classes now taught in Solar or HVAC field 4

Quarter ____ or Semester system ✓

Number of students enrolled in your area in 1979-80 school year: 83

Degree program ____ or Certificate 1 in Air Conditioning
1 in Advanced Heating
1 in Both

I would like to field test a section of the solar curriculum guide:

✓ yes ____ no

I would like to assist in reviewing sections of the guide:

✓ yes ____ no

I would like to recieve a guide when it is completed:

✓ yes ____ no

Thank you for your help.

Gene C. Walker

I am a registered Engineer in Iowa and Illinois and also do a little Industry Consulting beside the teaching functions

If I can help in any way please don't hesitate to contact me.

We have a place in the curriculum for (2) Solar classes – 1 beginning 1 advanced, However I have not developed these classes to date since Our program is only completing its second year in existence –

Good Luck in your endeavors.

Your name AL ANDREWS

Title CHAIRMAN

School Name ROCK VALLEY COLLEGE

Address 3301 N. MULFORD, ROCKFORD IL. 61101
Street City Zip

Telephone: 815 226-2650 NEW PHONE MAY 83 654-4400
Area Code

Number of classes now taught in Solar or HVAC field 2

Quarter ______ or Semester system 2

Number of students enrolled in your area in 1979-80 school year: 0 NEW 80-81

Degree program ✓ or Certificate ______

I would like to field test a section of the solar curriculum guide:

✓ yes ____ no

I would like to assist in reviewing sections of the guide:

✓ yes ____ no

I would like to recieve a guide when it is completed:

✓ yes ____ no

Thank you for your help.

Gene C. Walker

Your name Zollie W. Hall

Title Direction of Occupational Education

School Name Spoon River College

Address Rural Route One (Street) Canton, Il (City) 61520 (Zip)

Telephone: (309) 647 4645 (Area Code)

Number of classes now taught in Solar or HVAC field 0

Quarter ____ or Semester system ✓

Number of students enrolled in your area in 1979-80 school year: ____

Degree program ____ or Certificate ____

I would like to field test a section of the solar curriculum guide:

[✓ yes] no

I would like to assist in reviewing sections of the guide:

[✓ yes] no

I would like to recieve a guide when it is completed:

[✓ yes] no

Thank you for your help.

Gene C. Walker

Your name MARION ENERVOLD

Title BUILDING TRADES INSTRUCTOR

School Name GRUNDY AREA VOCATIONAL CENTER.

Address 1000 UNION ST. MORRIS, ILL. 60450
Street City Zip

Telephone: 815-942-4390
Area Code

Number of classes now taught in Solar or HVAC field NONE

Quarter ____ or Semester system ____

Number of students enrolled in your area in 1979-80 school year: 86

Degree program ____ or Certificate ____

HIGH SCHOOL JR. & SR.s

I would like to field test a section of the solar curriculum guide:

[✓ yes] ____ no

I would like to assist in reviewing sections of the guide:

[✓ yes] ____ no

I would like to recieve a guide when it is completed:

[✓ yes] ____ no

Thank you for your help.

Gene C. Walker

Your name Gary G. Perdew

Title Coordinator RAC

School Name College of Lake Co.

Address 19351 W. Washington Grayslake ILL. 60030
Street City Zip

Telephone: 312 - 223 6601 ex 322
Area Code

Number of classes now taught in Solar or HVAC field 9

Quarter ____ or [✓ Semester system]

Number of students enrolled in your area in 1979-80 school year: aprox 300

[✓ Degree program] or [✓ Certificate]

I would like to field test a section of the solar curriculum guide:

[✓ yes] no

I would like to assist in reviewing sections of the guide:

[✓ yes] no

I would like to recieve a guide when it is completed:

[✓ yes] no

Thank you for your help.

Gene C. Walker

Your name LOU KOMER

Title AREA CHAIRPERSON

School Name COMMUNITY H.S. DIST. 218

Address ____________________
Street City Zip

Telephone: ____________________
Area Code

Number of classes now taught in Solar or [✓ HVAC] field NEW PROGRAM

Quarter ________ or Semester system FOR 1981/82

Number of students enrolled in your area in 1979-80 school year: ________

Degree program ________ or Certificate ________

I would like to field test a section of the solar curriculum guide:

X yes ____no

I would like to assist in reviewing sections of the guide:

____yes ____no

I would like to recieve a guide when it is completed:

X yes ____no

Thank you for your help.

Gene C. Walker

Your name Dr. Richard J. Henry

Title Director, IRT Division

School Name Black Hawk College

Address 6600 34th ave, Moline, IL 61265
Street City Zip

Telephone: 309 796 - 1311
Area Code

Number of classes now taught in ~~Solar or~~ HVAC field ACRF

Quarter [✓] or Semester system ______

Number of students enrolled in your area in 1979-80 school year: 25

Degree program ______ or Certificate ______

I would like to field test a section of the solar curriculum guide:

___ yes ___ no Maybe?

I would like to assist in reviewing sections of the guide:

[✓ yes] ___ no

I would like to recieve a guide when it is completed:

[✓ yes] ___ no

Thank you for your help.

Gene C. Walker

Your name GREG LAY

Title Htg, A/c Instructor

School Name Lake Land College Vandalia Correctional Center

Address RT 51 N. Box 500 Vandalia 62471
Street City Zip

Telephone: 618-283-4170 Ext 126
Area Code

Number of classes now taught in Solar or HVAC field New Curriculum

Quarter ✓ or Semester system ____

Number of students enrolled in your area in 1979-80 school year: ____

Degree program ____ or Certificate ✓

I would like to field test a section of the solar curriculum guide:

____ yes ____ no Possibly, After Review

I would like to assist in reviewing sections of the guide:

✓ yes ____ no

I would like to recieve a guide when it is completed:

✓ yes ____ no

Thank you for your help.

Gene C. Walker

Your name Jim Upchurch

Title Director of Occupational Ed

School Name John Wood C C.

Address 1919 N 18th Quincy 62301
Street City Zip

Telephone: 217-224-6500
Area Code

Number of classes now taught in Solar or HVAC field 8

Quarter ____ or Semester system 40

Number of students enrolled in your area in 1979-80 school year: 50

Degree program 10 or Certificate 40

I would like to field test a section of the solar curriculum guide:

____yes ____no

I would like to assist in reviewing sections of the guide:

____yes ____no

I would like to recieve a guide when it is completed:

X yes ____no

Thank you for your help.

Gene C. Walker

Your name RAYMOND NEEDY.

Title AIR-CONDITIONING , REFRIGERATION PROGRAM COORDINATOR/INSTRUCTOR.

School Name TRITON COLLEGE.

Address 2000 FIFTH, AVE. RIVERGROVE, ILLINOIS. 60171
Street City Zip

Telephone: (312) 456-0300 EXT. 418 - 419
Area Code

Number of classes now taught in Solar or HVAC field 4 SECTIONS.

Quarter ____ or Semester system X

Number of students enrolled in your area in 1979-80 school year: 88

Degree program YES or Certificate YES

I would like to field test a section of the solar curriculum guide:

____yes __x__no

I would like to assist in reviewing sections of the guide:

____yes __x__no

I would like to recieve a guide when it is completed:

__x__yes ____no

I WOULD LIKE VERY MUCH TO RECEIVE INFORMATION CONCERNING YOUR PROGRAM AT COD.

Thank you for your help.

THANK YOU.

Gene C. Walker

Your name JOHN KONITZER

Title CHAIRMAN, NATURAL SCIENCE DIV.

School Name MC HENRY COUNTY COLLEGE

Address RT 14 + LUCAS RD. CRYSTAL LAKE IL. 60014
Street City Zip

Telephone: (815) 455-3700
Area Code

Number of classes now taught in Solar or HVAC field 1

Quarter 1 or Semester system

Number of students enrolled in your area in 1979-80 school year:

Degree program or Certificate

I would like to field test a section of the solar curriculum guide:

____yes ____no

I would like to assist in reviewing sections of the guide:

X yes ____no

I would like to recieve a guide when it is completed:

X yes ____no

Thank you for your help.

Gene C. Walker

Your name Dr. C. I. Washburn

Title Dean - Career Oriented Division

School Name Belleville Area College

Address 2500 Carlyle Road, Belleville Ill. 62221
Street City Zip

Telephone: (618) 235-2700
Area Code

Number of classes now taught in Solar or [✓ HVAC field 10]

Quarter ____ or Semester system O

Number of students enrolled in your area in 1979-80 school year: 150 +

Degree program X or Certificate X

I would like to field test a section of the solar curriculum guide:

____yes X no

I would like to assist in reviewing sections of the guide:

____yes X no

I would like to recieve a guide when it is completed:

X yes ____no

We are not currently offering any courses in solar but are considering to do so.

Thank you for your help.

Gene C. Walker

Your name John Murphy

Title CHAIRperson - Engrg. Math. & Phy Sci.

School Name Illinois Valley Comm. Col

Address Route One Oglesby, IL. 61348
Street City Zip

Telephone: 815 - 224 - 2720
Area Code

Number of classes now taught in Solar or HVAC field None

Quarter ______ or Semester system —

Number of students enrolled in your area in 1979-80 school year: —

Degree program — or Certificate —

I would like to field test a section of the solar curriculum guide:

yes [✓ no]

I would like to assist in reviewing sections of the guide:

yes [✓ no]

I would like to recieve a guide when it is completed:

[✓ yes] no

Thank you for your help.

Gene C. Walker

Your name ORELL R. VANDERWATER

Title DEAN, ON CAMPUS INSTRUCTION

School Name LINCOLN LAND COMM. College

Address SHEPHERD Rd. Springfield, Ill 62708
Street City Zip

Telephone: 217 786-2269
Area Code

Number of classes now taught in Solar or HVAC field 0

Quarter ___ or Semester system ✓

Number of students enrolled in your area in 1979-80 school year: ___

Degree program ___ or Certificate ___

I would like to field test a section of the solar curriculum guide:

yes [✓ no] NOT READY YET FOR THIS PHASE

I would like to assist in reviewing sections of the guide:

[✓ yes] no

I would like to recieve a guide when it is completed:

[✓ yes] no

Thank you for your help.

Gene C. Walker

Your name H. Gerber

Title Chairman

School Name Prairie State College

Address 202 S. Halsted Chgo Hts. IL 60411
Street City Zip

Telephone: (312) 756-3110
Area Code

Number of classes now taught in Solar or HVAC field 5

Quarter ____ or Semester system ✓

Number of students enrolled in your area in 1979-80 school year: 25

Degree program ____ or Certificate ✓

I would like to field test a section of the solar curriculum guide:

☐ yes ☒ no

I would like to assist in reviewing sections of the guide:

☐ yes ☒ no

I would like to recieve a guide when it is completed:

☒ yes ☐ no

Thank you for your help.

Gene C. Walker

We are in the process of getting an instructor and we are not in a position to help.

## Problems

The main problem with the designated project was that there was an excessive amount of research, writing, and planning work for one person to accomplish in the allotted time.

Other problems encountered were due to the newness of the solar field--contacting anyone with expertise in the field was difficult. Meeting with these individuals was close to impossible due to their busy schedules. They all wanted to help, but just didn't have the time.

Initial funding agreement was looked at as a duplicate of what Southern Illinois University had done in 1979. This was gone over and the Director of Southern's grant was contacted and meetings were held to determine how College of DuPage's project would differ.

The Solar Energy Installers Curriculum Guides are intended to be used in conjunction with the Illinois Solar Energy System's Installation Training Program.

# PUBLICITY

# College of DuPage News Release

Glen Ellyn, Illinois 60137

**Release Number:** NR 79-394

**Date:** November 30, 1979

**For further information contact:**
Ruth Hallenstein
858-2800, Ext. 2371

NEW AIR CONDITIONING COURSE OFFERED AT COLLEGE OF DuPAGE

A new air conditioning course designed for those who have indicated a desire for knowledge in the alternate energy field is being offered in the winter quarter by College of DuPage's Air Conditioning, Refrigeration, and Heating Department.

Air Conditioning 106 is a beginning course which will endeavor to teach the fundamental concepts of appropriate technologies. Focus will be on energy and the specific concepts of solar energy. Energy today, solar active and passive, wind, and biomass will be covered.

At the conclusion of the course, students will be able to evaluate the worth and value of each technology as it applies to the northern Illinois region, and determine what courses to specialize in to obtain needed knowledge to become a technician in a particular alternate energy area such as active system solar installation, passive solar installation, wind machine, errector, etc.

This course will be given twice, Tuesdays (code 9A4NA) and Thursdays (code 9A4NB) from 5:30 to 10:20 p.m. in Room 2021 of Building A on the campus, 22nd Street and Lambert Road, Glen Ellyn. The Tuesday class begins Jan. 8 while the Thursday class starts on Jan. 3.

The four-credit hour course is comprised of three hours of lectures and two hours of lab work. There will be several field trips and speakers.

For more information, call 858-2800, ext. 2322.

**College of DuPage**
**News Release**

Glen Ellyn, Illinois 60137

| Release Number: | Date: | For further information contact: |
|---|---|---|
| NR 79-418 | December 14, 1979 | Ruth Hallenstein<br>858-2800, Ext. 2371 |

COLLEGE OF DuPAGE FACULTY MEMBERS RECEIVE GRANTS

Two College of DuPage faculty members are the recipients of curriculum grants from the Department of Adult Vocational and Technical Education of the Illinois State Board of Education.

Robert G. Huntley, coordinator of the ornamental horticulture program, received a grant of $18,068 which he will use to develop three cirriculums dealing with turf management, floriculture, and gardening-grounds. He will receive one half release time from his teaching duties for this work.

Huntley's cirriculums will be field tested in other institutions and could be used statewide. His proposal for the grant was selected from statewide competition.

Also selected in statewide competition is Gene C. Walker, coordinator of the college's air conditioning/refrigerator program. His $10,748 grant is to be used to develop a curriculum in the air conditioning field.

He also will have his work field tested in other institutions with a possibility of statewide use. Walker will receive one-third release time from his duties at the college to undertake this work.

-30-

# ADVISORY BOARD MEETINGS

# and

# MATERIALS DISCUSSED

COLLEGE OF DuPAGE ◆ GLEN ELLYN ILLINOIS 60137 ◆ TELEPHONE 312-858-2800

## COLLEGE OF DuPAGE - ADVISORY COMMITTEE - AIR CONDITIONING

Shiree Vaughn
Solar Ray Systems Inc.
P.O. Box 277
Peoria, IL. 61650
Phone: 309-686-1900

Mr. T.L. Bremer
Bremer Sheet Metal
849 Main Street
Glen Ellyn, IL. 60137
Phone : 469-2330

Mr. Harold S. Gray, President
Control'd Engineering Supply
299 Roosevelt Road
Glen Ellyn, IL. 60137
Phone: 469-7300

Mr. Harold M. Levy
Air Conditioning, Heating & Refrig.
Kennedy-King College
City Colleges of Chicago
7047 South Stewart Avenue
Chicago, IL. 60621
Phone: 376-3505

Mr. Lawrence Felker-Rep. by Joe
Executive Vice President
Robert Barclay Company
2323 West Fulton
Chicago, Ill. 60612
Phone: 858-0888 (Joe)

Mr. George Ruble
Central Furnace Supply
River Road and Ogden Ave.
Post Office Box 66
Naperville, IL. 60540
Phone: 355-1220

Mr. Robert Forty
Energy Services Company
4659 Old Tavern Road
Lisle, IL. 60532
Phone: 420-2275

Mr. David J. Mincheski
Dacar Heating & Cooling
76 North Eisenhower Lane
Lombard, IL. 60148
Phone: 293-0060

Lou Kohley
Instructor Air Conditioning
College of DuPage
Glen Ellyn, IL 60137

Mr. Gene May, Service Manager
Youngren's Inc.
736 Newhaven
Aurora, IL. 60606
Phone: 897-5248

Mr. Michael Kirkpatrick
K & M Heating & Air Conditioning
625 Gary Avenue
Wheaton, IL. 60185
Phone: Bus. 665-2297 Home 682-3059

Farell W. Pelfrey
Environmental Energy Systems Inc.
The Energy Store
5A Maravets
Aurora, IL. 60505
Phone: 739-9213

James Fitzgerald Michael Hudspeath
Solar Energy Products
7855 Gross point Rd.
Skokie, IL. 60077
Phone: 677-0950

Jack Zaruba
J.Z. Alternate Energy
Products Corp.
614 Willow Road
Elmhurst, IL. 60126
Phone: 530-7528

James McGowan
Solar Products Inc.
2419 20th Street
Rockford, IL. 61108
Phone: 397-0536

James A. Hartley
NISEA
P.O. Box 1592
Aurora, IL. 60507
Phone: 377-1590

January 15, 1980

Mr. James A. Hartley
NISEA
P.O. Box 1592
Aurora, IL 60507

Dear Mr. Hartley:

It is my privilege to forward to you this notification of appointment to the Advisory Committee of the Air Conditioning and Refrigeration Program.

The function of the Advisory Committee is one of great importance to a community college and we are pleased you have found it possible in your busy schedule to render this service to us.

College of DuPage, like most community colleges, will undertake a comprehensive program including many offerings in occupational fields. Curricula in this latter context needs constant surveillance by people of knowledge in the area.

Hence, the Advisory Committee renders a service not only in appraising our existing program but in advising us as to changes that will keep us abreast of the current thinking in the technology. The deliberations of the Advisory Committee are of great import to us as we wrestle with the problem of revising and updating curriculum and teaching practices.

Please accept my congratulations on this appointment and my warmest appreciation of your willingness to serve.

Sincerely,

Dr. H. D. McAninch
President

COLLEGE OF DUPAGE ◆ GLEN ELLYN ILLINOIS 60137 ◆ TELEPHONE 312·858·2800

January 15, 1980

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Rockford, IL 61108

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COLLEGE OF DuPAGE ◆ GLEN ELLYN ILLINOIS 60137 ◆ TELEPHONE 312·858·2800

January 15, 1980

Mr. Jack Zaruba
J. Z. Alternate Energy
Products Corporation
614 Willow Road
Elmhurst, IL 60126

Dear Mr. Zaruba:

It is my privilege to forward to you this notification of appointment to the Advisory Committee of the Air Conditioning and Refrigeration Program.

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President

COLLEGE OF DuPAGE ◎ GLEN ELLYN ILLINOIS 60137 ◎ TELEPHONE 312·858·2800

January 15, 1980

Mr. James Fitzgerald
Solar Energy Products
7855 Gross Point Road
Skokie, IL 60077

Dear Mr. Fitzgerald:

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Sincerely,

Dr. H. D. McAninch
President

COLLEGE OF DuPAGE ⊕ GLEN ELLYN ILLINOIS 60137 ⊕ TELEPHONE 312-858-2800

January 15, 1980

Mr. Farell W. Pelfrey
Environmental Energy Systems Inc.
The Energy Store
5A Maravets
Aurora, IL 60505

Dear Mr. Farell:

It is my privilege to forward to you this notification of appointment to the Advisory Committee of the Air Conditioning and Refrigeration Program.

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Sincerely,

Dr. H. D. McAninch
President

COLLEGE OF DUPAGE GLEN ELLYN ILLINOIS 60137 TELEPHONE 312 858 2800

January 15, 1980

Ms. Shiree Vaughn
Solar Ray Systems, Inc.
P.O. Box 277
Peoria, IL 61650

Dear Ms. Vaughn:

It is my privilege to forward to you this notification of appointment to the Advisory Committee of the Air Conditioning and Refrigeration Program.

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Sincerely,

Dr. H. D. McAninch
President

# IMPORTANT NOTICE

There will be a meeting of the Air Conditioning Refrigeration and Heating Departments Advisory Board Committee on December 11, 1979. Please leave this date open and mark it on your calendar.

The Advisory Board is a very important part of a community college. The only way I can get input on what the community feelings are on what we are doing here at the college is through the people on my board.

If you cannot make the meeting, please send someone affiliated with you in your place. I need your input.

The agenda for the meeting will be as follows:

1) Meet at 1:00 PM at the school in room A1047 on December 11, 1979. (This is in A Building, Lower Level, far northeast corner)
2) Introduce new alternate energy course.
3) Discuss grant for development of solar installer courses.
4) Opinions on job competencies determined for all aspects of our trade. Go over career ladders for student advancement.
5) Look at new training equipment.
6) Open for ideas and discussion.

Please reply to this notice as to whether you will attend or not. Call 858-2800, ext 2322.

Sincerely,

Gene C. Walker

Gene C. Walker
Coordinator, Air Conditioning/Refrigeration

P.S. This is a very important meeting to help set up guidelines for the State Grant program development. Please attend.

COLLEGE OF DuPAGE ⊕ GLEN ELLYN ILLINOIS 60137 ⊕ TELEPHONE 312-858-2800

COLLEGE OF DuPAGE
Building A - Room 1047
AIR CONDITIONING

ADVISORY COMMITTEE MINUTES

CALLED TO ORDER: December 11, 1979 - 11:15 AM

PRESENT:

Farell Pelfrey-owner of Environmental Energy Systems, Inc.
James Hartley-President Northern Illinois Solar Association
Robert Forty-owner of Energy Services Company
Michael Hudspeath-Solar Energy Products
Lou Kohley-College of DuPage instructor AC/R Program
W. R. Johnson-Associate Dean of Technology, College of DuPage
Michael Kirkpatrick-K & M Heat and Cooling, former College of DuPage student

MINUTES:

Informed Advisory Committee that curriculum was approved by the state for Air Conditioning 106. Two sections are being offered this winter. As yet enrollment is small, but perhaps advantageous for the first Alternate Energy course being offered at College of DuPage. This perhaps was due to lack of publicity in the Winter Quarterly and other media.

Committee discussed and reviewed competency statements that Mr. Walker had worked up. Many additions to competencies and revisions were made.

Southern Illinois University's curriculum was reviewed. All members were given copies and asked to evaluate the installation section. Solar industry needs both installers and salesmen. It was suggested by the committee that the college work with manufacturers and contractors to promote solar energy in our area.

The old farmhouse located on Park Avenue, in Glen Ellyn, will be converted into an alternate energy building, so the people of the community can observe solar energy in action. The farmhouse garage will possibly be converted into a solar greenhouse for public viewing. It is important that the public be shown what can be done with active and passive solar systems.

It was agreed:

Air Conditioning 106 - Alternate Energy, will offer a step-by-step course covering basic solar information.

A competency curriculum will be established for solar installation.

Course would stress theory with use of equipment in lab.

Training in sheet metal, piping, etc. would be met in previous Air Conditioning classes.

The students should be made aware of union problems and availability of jobs.

Alert students, that due to infancy of solar energy, most jobs are customized and student must be adaptable and precise in job performance.

ADJOURNMENT: The meeting was adjourned at 3:40 PM.

COLLEGE OF DuPAGE GLEN ELLYN ILLINOIS 60137 TELEPHONE 312-858-2800

# AIR CONDITIONING AND REFRIGERATION AND HEATING PROGRAM

Gene C. Walker
Coordinator
A-2025c Ext. 2088

Revised 4-10-80

# INTRODUCTION

The ever-increasing utilization of air conditioning, heating and refrigeration by all segments of our society has been one of the great developments of progress in the twentieth century. Air conditioning is generally thought of in terms of personal comfort; however, overall environmental control has made a tremendous impact in food preservation, medicine and surgery, electronic computer systems, the space program, the national defense system, and many other fields. If environmental control requirements had not progressed rapidly to meet the demands of the fields requiring its capabilities, many of the aforementioned advancements would not be possible.

The rapid growth, tremendous expansion, and future developments in this field place a great demand on this industry to meet the installation and service requirements of industry and the public. A shortage of skilled craftsmen exists in the installation, maintenance, and repair of environmental control systems.

In the air conditioning, heating, and refrigeration field, manpower forecasts indicate approximately 50,000 to 100,000 additional positions will need to be filled by qualified service personnel in the next five years. The growth and expansion that is now taking place foretells what we may expect in the near future; and it is urgent that we do everything possible to develop this needed manpower.

With refrigeration and air conditioning no longer considered a luxury, but rapidly becoming a necessity in more and more aspects, full-time maintenance men are required by large department stores, factories, food-store, and restaurant chains, and other users of environmental control equipment. With new schools being designed to encompass year-round air conditioning, their maintenance people must be qualified to take care of minor problems that occur in and with the equipment.

Utility companies are also in need of qualified service personnel, since they either sell and install air conditioning equipment--either reciprocating or absorption--or they assist dealers who are handling equipment that utilizes their product.

The medical field is utilizing more and more refrigeration in the work and study of pathology and surgery, and the need for service personnel in that area is also on the increase.

The space field, now and in the future, will put a drain on available skilled personnel in the commercial and industrial area that will need to be replaced and supplemented by "new blood."

Upon completion of the air conditioning courses, the student should be qualified for successful entry into the air conditioning, heating, and refrigeration service field. With further training being offered by prospective employers at the dealer, distributor, and mechanical contractor level, the graduate of this program should be able to assist the air conditioning, heating, and refrigeration mechanic in the installation of necessary equipment for the completion of residential and commercial projects. This includes the installation of mechanical equipment, also ductwork, and electric wiring that may be necessary for the overall control of the installation.

After on-the-job experience, the graduate should also be able to assist the mechanic in the servicing of the various air conditioning, heating, and refrigeration components, the trouble-shooting of the systems, and the preventive maintenance that is required of all mechanical equipment.

This individual should be able to perform numerous tasks around the service shop pertaining to the repair of equipment that is brought in from the job site, such as compressors and window air conditioners.

## PROGRAM OBJECTIVES
## AIR CONDITIONING AND REFRIGERATION

Upon completion of the Air Conditioning and Refrigeration program, the student will be able to:

1. Be familiar with all types of equipment on the market today.
2. Understand and use all types of tools available to the serviceman or installer.
3. Diagnose and repair various types of control systems.
4. Learn installation of all types of equipment.
5. To give the fundamentals of the refrigeration cycle to the student.
6. To provide the information on each part of the system: how it functions in the system, what can go wrong with it; and what causes it to break down.
7. Familiarize the student with all tools and their uses.
8. Installation procedures for all types of equipment.
9. Safety procedures to be followed when handling various tools during installation or service.
10. To give the students a wide view of the jobs available to them by taking field trips to different types of installations and having speakers from various companies.
11. By advising them to take supportive courses such as business, accounting, math, and english. They can be guided into the industry as service technicians, sales personnel or small business owners.
12. Identify all types of jobs available to him in the industry:
    a. Equipment Installer
    b. Equipment Serviceman
    c. Contractor
    d. Maintenance Engineer
    e. Salesman
13. Enter into any phase of the industry and become immediately productive with a minimum amount of training.
14. Advance in his present job to one of higher position.
15. By taking supportive courses along with the air conditioning be able to make a career change.
16. Help build a strong self-confidence in each student involved in the program.
17. Develop communication skills.
18. Have extensive knowledge in both the technical and practical application of air conditioning.

## COURSES NOW OFFERED

| COURSE NUMBER | TITLE |
|---|---|
| 100 | Introduction to Controls |
| 101 | Basic Refrigeration |
| 102 | Cycle and System Components |
| 103 | Air Conditioning Systems |
| 105 | Instruments<br>(Introduction to Service Procedures) |
| 110 | Basic Control Systems |
| 141 | Automotive Air Conditioning |
| 142 | Automotive Air Conditioning Controls |
| 161 | Introduction to Sheet Metal |
| 162 | Sheet Metal Layout and Fabrication |
| 180 | Gas Heating |
| 182 | Oil Heating |
| 184 | Electric Heating |
| 186 | Piping and Accessories<br>(Hydronic Heating and Cooling) |
| 199 | Internship |
| 201 | Service Procedures |
| 202 | Control Systems |
| 210 | Commercial Refrigeration |
| 220 | Installation |
| 230 | Advanced Controls |
| 240 | Duct Design |
| 250 | Air Distribution |
| 261 | Advanced Sheet Metal |
| 262 | Advanced Sheet Metal |
| 263 | Advanced Sheet Metal |
| 299 | Internship |
| 106 | Solar Energy and Other Alternatives |

## Individual Course Objectives

### Air Conditioning and Refrigeration 100

Credit hours 3, lecture 2 hours, lab 2 hours. Prerequisite: none

This course is designed to acquaint the student with fundamental electrical concepts essential to understanding the function and application of electric motors and automatic temperature controls.

### Air Conditioning and Refrigeration 101

Credit hours 3, lecture 3 hours. Prerequisite: none

1. To familiarize the student with proper definitions on terms used in Air Conditioning.
2. To develop an understanding of various comfort conditions and what affects them.
3. The proper use of psychometrics by the service technicians.
4. To become familiar with heat loss and heat gain.

### Air Conditioning and Refrigeration 102

Credit hours 3, lecture 3 hours. Prerequisite AC & R 101

1. To familiarize the students with the four major components that make up the refrigeration system.
2. To show how various undesirable conditions can effect the overall efficiency.
3. To demonstrate basic service procedures, which help improve overall operation.

### Air Conditioning and Refrigeration 103

Credit hours 3, lecture 3 hours. Prerequisite AC & R 102

1. To acquaint the student with refrigeration systems other than the reciprocating type.
2. To show the similarities and differences between these systems.
3. To introduce the students to fan theory and total comfort.

### Air Conditioning and Refrigeration 105

Credit hours 4, lecture 3 hours, lab 2 hours. Prerequisite: none

1. To familarize students with soldering tools
2. To develop and understanding of the pressures with which refrigeration personnel must be concerned.
3. To develop the techniques used and proper care of gauges involved in reading pressures.
4. To develop proper use and care of electrical meters.
5. To develop proper attitudes in the safe usage of tools.

## Air Conditioning and Refrigeration 110

Credit hours 4, lecture 3 hours, lab 2 hours, Prerequisite AC & R 100

To train the student in the theory of operation, installation and servicing of:

1. Domestic refrigerator controls.
2. Domestic freezer controls.
3. Commercial refrigeration controls.
4. Combinations and variations of above systems.

## Air Conditioning and Refrigeration 141

Credit hours 3, lecture 2 hours, lab 2 hours. Prerequisite: none

1. To inform trainees of the competencies required and the employment opportunities available in Automotive Air Conditioning.
2. To acquaint the students with the history of air conditioning in the automotive field.
3. To familiarize students with the terminology used in the air conditioning field.
4. To familiarize the students with the major system components.
5. To develop the proper systematic procedure needed in trouble diagnosing.
6. To develop the proper use of specialized tools needed in this area.

## Air Conditioning and Refrigeration 142

Credit hours 3, lecture 2 hours, lab 2 hours. Prerequisite: AC & R 141

1. To acquaint the students with the different types of controls in general use today.
2. To inform the students about the various ways of wiring and problems that arise in it.
3. To give the students knowledge of the terms used and locations of various parts in the control system.
4. To develop the proper attitude needed in adjusting the numerous controls involved in automotive air conditioning.

## Air Conditioning and Refrigeration 161 - 162 - 261 - 262 - 263

Credit hours 3, lecture 2 hours, lab 2 hours. Prerequisite of each other

1. To familiarize the student with the tools used in designing and assembling sheet metal.
2. To instruct the student in the proper fitting layout and assembly procedures.
3. Work with each student on an individual basis so that he gets proper instruction in whichever phase of sheet metal he is interested in.
4. Student advances through all phases of sheet metal, course by course.

## Air Conditioning and Refrigeration 180 - 182 - 184

Credit hours 3, lecture 2 hours, lab 2 hours. Prerequisite: AC & R 100

1. To instruct the student in the three types of fuel used in most domestic heating.
2. To inform the student in the use of various tools used in servicing heating units.
3. To instruct the student in the sequence of operation of each type of heating system and the controls and safeties that are common to each.
4. To instruct in the service involved in each type.
5. To instill into each student the necessary safety precautions used in working on each type of system.

## Air Conditioning and Refrigeration 186

Credit hours 3, lecture 2 hours, lab 2 hours. Prerequisite: none

The objective of the curriculum is to provide the student with sufficient knowledge to be able to design and install residential hydronic heating systems.

## Air Conditioning and Refrigeration 199 - 299

Credit hours 6. Prerequisite: Consent of instructor, AC & R 101

1. To give students an overall view of the types of employment available to them.
2. By working with various employers arrange internships in the industry.

## Air Conditioning and Refrigeration 201

Credit hours 4, lecture 3 hours, lab 2 hours. Prerequisite AC & R 105

1. To instruct the student in the proper use of gauges and meters.
2. Diagnose problems in the equipment using the meters.
3. Instruct in safety precautions.

## Air Conditioning and Refrigeration 202

Credit hours 4, lecture 3 hours, lab 2 hours. Prerequisite AC & R 110

The objective of this course is to provide the student with the necessary knowledge and physical skills to install and troubleshoot basic control systems.

## Air Conditioning and Refrigeration 210

Credit hours 4, lecture 3 hours, lab 2 hours. Prerequisite: AC & R 201

1. To acquaint the student in the differences between residential and commercial equipment.
2. To familiarize the student with commercial controls.
3. Problems in commercial equipment.

### Air Conditioning and Refrigeration 220

Credit hours 4, lecture 3 hours, lab 2 hours. Prerequisite: AC & R 201

1. Acquaint the student with problems that arise in a residential installation.
2. Proper use of tools which make the installation job easier.
3. Show all hidden factors that might exist during installation which would add to the cost of the job.

### Air Conditioning and Refrigeration 230

Credit hours 4, lecture 3 hours, lab 2 hours. Prerequisite: AC & R 202

The objective of Air Conditioning and Refrigeration 230 is to provide the student with the fundamentals and a solid background in the area of sophisticated commercial controls, i.e. modulating electric and pneumatic control systems.

### Air Conditioning and Refrigeration 240

Credit hours 3. Consent of instructor.

1. To familiarize the student with the various methods of duct sizing.
2. To show how duct work is put onto a set of blueprints.
3. Show relationship between BTU and CFM.
4. Proper use of duct sizing calculator.

### Air Conditioning and Refrigeration 250

Credit hours 3, lecture hours 2, lab 2 hours. Prerequisite: AC & R 240

1. To show cost saving through proper air balancing.
2. To introduce the student to the meters used in balancing.
3. The relationship between proper duct sizing and proper air movement.

### Air Conditioning & Refrigeration 106

Credit hours 4, lecture hours 3, lab 2 hours.

1. History & general concepts
2. Solar energy & other technologies
3. Solar passive vs. solar active

## AIR CONDITIONING AND REFRIGERATION - OPTIONS

### Control Option

| | | |
|---|---|---|
| AC & R 100 | Introduction to Controls | 3 |
| AC & R 110 | Basic Controls | 4 |
| AC & R 202 | Control Systems | 4 |
| AC & R 230 | Advanced Controls | 4 |

### Heating Option

| | | |
|---|---|---|
| AC & R 180 | Gas Heating | 3 |
| AC & R 182 | Oil Heating | 3 |
| AC & R 184 | Electric Heating | 3 |
| AC & R 186 | Piping and Accessories (Hydronic heating and cooling) | 3 |
| AC & R 106 | Solar Heating & Other Alternatives | 4 |

### Automotive Option

| | | |
|---|---|---|
| AC & R 141 | Automotive Air | 3 |
| AC & R 142 | Automotive Air Conditioning Controls | 3 |

### Sheet Metal Option

| | | |
|---|---|---|
| AC & R 161 | Intro | 3 |
| AC & R 162 | Sheet Metal | 3 |
| AC & R 240 | Duct Design | 3 |
| AC & R 261 | Advanced Sheet Metal | 3 |
| AC & R 262 | Advanced Sheet Metal | 3 |
| AC & R 250 | Air Distribution | 3 |
| AC & R 263 | System Design and Layout | 3 |

# DEGREE AND CERTIFICATE PROGRAM

Before entering either of these programs it is highly advised that all potential students meet with the coordinator or one of the instructors in the Air Conditioning program

Air Conditioning and Refrigeration

Suggested Program - Certificate Seeking

| | | |
|---|---|---|
| **FIRST QUARTER** | | |
| AC & R 100 | Introduction to Controls | 3 |
| AC & R 101 | Basic Refrigeration | 3 |
| **SECOND QUARTER** | | |
| AC & R 102 | Cycle and System Components | 3 |
| AC & R 105 | Instruments | 4 |
| **THIRD QUARTER** | | |
| AC & R 103 | Air Conditioning Systems | 3 |
| AC & R 110 | Basic Controls | 4 |
| **FOURTH QUARTER** | | |
| AC & R 201 | Service Procedures | 4 |
| AC & R 202 | Control Systems | 4 |
| **FIFTH QUARTER** | | |
| AC & R 210 | Commercial Refrigeration | 4 |
| AC & R 220 | Installation | 4 |
| **SIXTH QUARTER** | | |
| AC & R 230 | Advanced Controls | 4 |

It is also highly recommended that students take all heating and several sheet metal courses so as to develope a well rounded and season to season education.

## AIR CONDITIONING AND REFRIGERATION

Suggested Program - Degree Seeking
93 - hours Required for Degree

| Technical Courses | Description | Credit Hours |
|---|---|---|
| Air Conditioning 100 | Intro. to Controls | 3 |
| " " 101 | Basic Refrigeration | 3 |
| " " 102 | Cycle and System Components | 3 |
| " " 103 | Air Conditioning Systems | 3 |
| " " 105 | Instruments | 4 |
| " " 110 | Basic Control Systems | 4 |
| " " 161 | Intro. to Sheet Metal | 3 |
| " " 162 | Sheet Metal Layout and Fabrication | 3 |
| " " 201 | Service Procedures | 4 |
| " " 202 | Control Systems | 4 |
| " " 210 | Commercial Refrigeration | 4 |
| " " 220 | Installation | 4 |
| " " 230 | Advanced Controls | 4 |
| " " 240 | Duct Design | 3 |
| | | 49 Total |

## GENERAL EDUCATION DISTRIBUTION REQUIREMENTS

| | Assoc. in Applied Science (A. A. S.) Credit Hours[a] |
|---|---|
| Communications<br>English, (Composition only) Speech, Journalism | 5 |
| Humanities<br>Art, English (Literature only) French, German, History[b], Humanities, Italian, Music Philosophy, Russian, Spanish, Theater | 5 |
| Social/Behavioral Sciences<br>Anthropology, Economics, Education, Geography, History[b] Political Science, Phychology, Social Science, Sociology | 5 |
| Science/Mathematics<br>Anatomy & Physiology, Biology, Botany, Chemistry, Earth Science, Mathematics, Microbiology, Physics, Zoology | 5 |

Total of 30 required
10 extra from any category

[a] Select General Education courses from the preparation guides in the S.P.B.

[b] History may be included in either Humanities or Social/Behavioral Science, but not both.

## ASSOCIATE IN APPLIED SCIENCE DEGREE PROGRAM

The Associate in Applied Science (A.A.S.) degree represents the completion of a program which has been designed to focus on specialized occupational or technical curricula. Students are generally anticipating seeking employment in their field of specialization following the awarding of the A.A.S. degree. However, some fields may lead to baccalaureate degrees at some four-year institutions. Students planning to pursue a baccalaureate degree in their field of specialization should be aware of the requirements of the transfer institutions.

Requirements for an Associate in Applied Science Degree

Each candidate for an A.A.S. degree shall:

1. Satisfy all general degree requirements and regulations.
2. Complete a minimum of 30 quarter hours of general education credit with at least 5 quarter hours in each of the following categories: Communications, Humanities, Science/Math, and Social/Behavioral Science (as identified on the following pages.)
3. Complete the minimum number of credits specified in the technical course area as stated in the occupational preparation guides or as approved by the deans.
4. Adhere to additional requirements and limitations specified in the addendum.

## ASSOCIATE IN GENERAL STUDIES DEGREE

The Associate in General Studies (A.G.S.) degree represents the completion of a program which has been designed by a student in consultation with the student's advisor. This degree permits the student a maximum amount of diversification and may include occupational/technical or general education courses.

Requirements for an Associate in General Studies Degree

Each candidate for an A.G.S. degree shall:

1. Satisfy all general degree requirements and regulations.
2. Complete a minimum of 40 quarter hours of General Education Credit with at least 10 quarter hours in each of the following categories: Communications, Humanities, Science/Math, and Social/Behavioral Science.
3. Take not more than 45 quarter hours of credit from one subject area.
4. Adhere to additional requirements and limitations specified in the addendum.

IMPORTANT NOTES

1. The responsibility for proper registration each quarter rests with the student. The planning of courses relevant to future goals as well as satisfying graduation requirements are the responsibilities of the student.
2. All students intending to transfer, whether or not they are seeking a College of DuPage associate degree, are encouraged to plan their programs according to the requirement of the transfer institution as specified in its catalog and in consultation with an advisor.
3. Degree and major requirements at senior institutions may require more than two academic years of study beyond an associate degree to earn a bachelor's degree.

4. Courses numbered below 100 (060, 070, 080, etc.) and D11 100 may represent courses not usually found in the curriculum of the four-year universities, and therefore may not apply toward specific degree requirements.

5. Some College of DuPage courses have been designed for two-year curriculums. Although they are considered college level, they may not meet the objectives of a bachelors degree program and, therefore may not be transferable.

6. When a student breaks enrollment for more than four quarters, he is then subject to the catalog that is current at the time of his re-entry into enrollment.

7. Students with special problems related to degree requirements may appeal to the Academic Regulations Committee. Information about this process may be obtained from the Office of the Dean of Students.

8. Twenty S / F credits are the maximum allowable toward an Associate in Arts, Associate in Science, or the Associate in Applied Science Degree.

9. Up to six quarter credits in different physical education activity courses may be counted toward an associate degree.

10. Only three quarter-credits in EDUC 110 may be counted toward an associate degree.

11. Up to 65 quarter credits earned by demonstrated competence may be counted toward an associate degree.

## PURPOSE OF GENERAL EDUCATION REQUIREMENTS

The faculty of College of DuPage believes that each person receiving an associate degree should include a diversity of experiences in his collegiate course work. This belief has resulted in the establishment of a General Education requirement for each associate degree. The aims of General Education are to encourage the individual to have a variety of experiences that help him (1) broaden his academic understanding, (2) increase his knowledge of the relationship between various academic disciplines, (3) develop and evaluate his values in relationship to himself, others, and his environment. The faculty of the college does not believe that every student must take the same courses to meet these stated aims of general education. Therefore, flexibility exisits for each student to select from a distribution of courses in each of the four areas of Communication, Humanties, Science/Math and Social/Behavioral Science.

## GENERAL EDUCATION COURSE DISTRICUTION

Communications
English (Composition only) ALL 101-102-103
Speech
Journalism

Humanities
Art
English (Literature only) ALL 110-120-200-230
French
German
History
Humanities

**Humanities Continued**
Music
Philosophy
Russian
Spanish
Theater

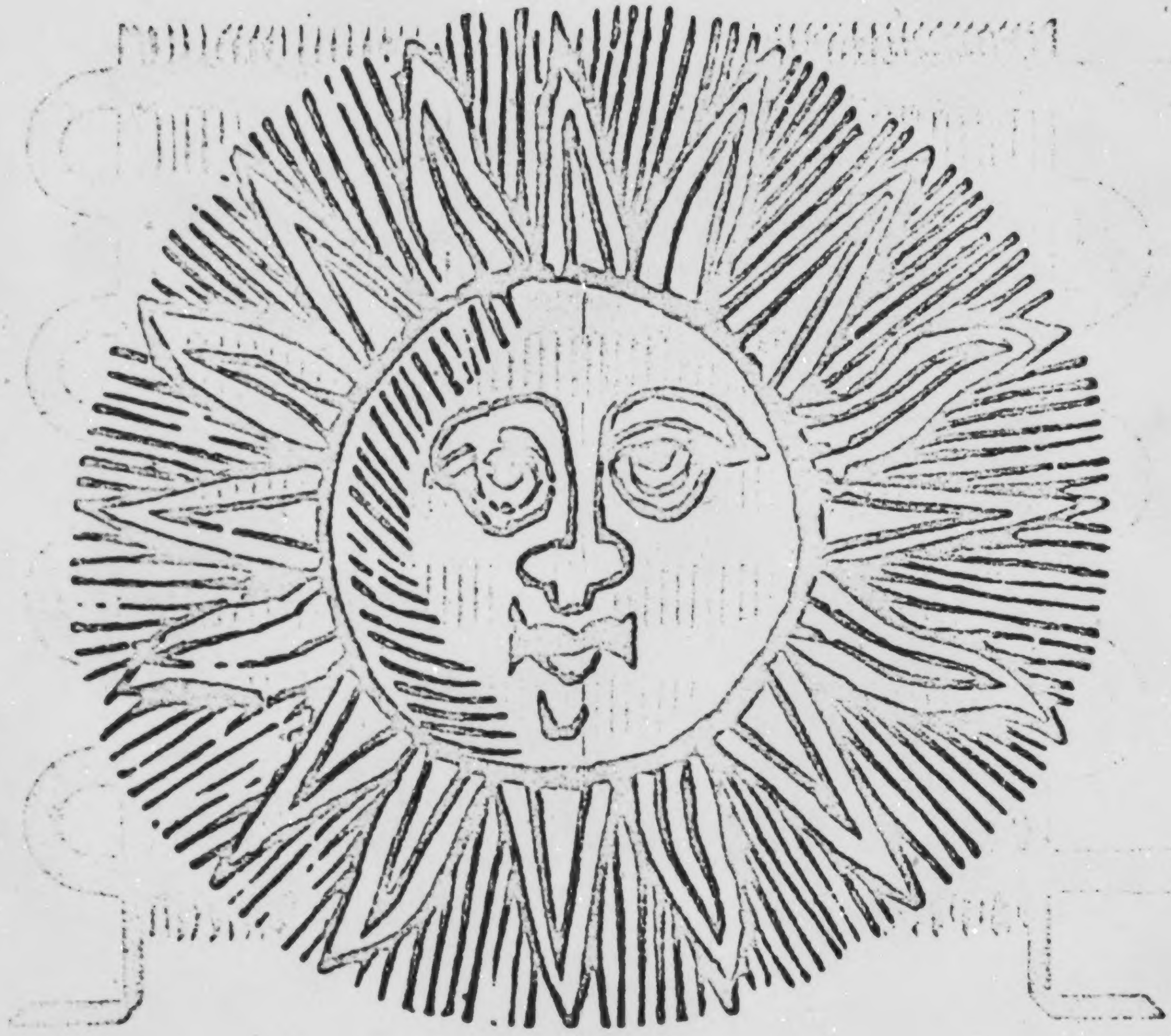
**Science Mathematics**
Anatomy & Physiology
Biology
Botany
Chemistry
Earth Science
Mathematics
Microbiology
Physics
Zoology

**Social/Behavioral Science**
Anthropology
Economics
Education
Geography
History
Political Science
Psychology
Social Science
Sociology

History may be included in either Humanities or Social/Behavioral Science but not both.

College of DuPage

# Air Conditioning & Refrigeration



**About the Program**

As our society places increasing emphasis on the comfort of air conditioning and the necessity of refrigeration, there is a corresponding demand for qualified personnel to ensure trouble-free operation of air conditioning and refrigeration equipment. This demand extends from manufacturers and distributors to local dealers and contractors.

In response to this need from the community, College of DuPage has developed an Air Conditioning and Refrigeration Program to give students a solid technological background in the theory, systems, components and controls of air conditioning and refrigeration, along with supplementary courses in mathematics, electricity, drafting and physics.

Upon successful completion of the program, a student is awarded an Associate in Applied Science degree and is prepared for employment in commercial or private installation, maintenance and repair of air conditioning and refrigeration equipment. Students may choose to enroll in a certificate program which focuses on courses in air conditioning and refrigeration only.

**Your Future in Air Conditioning and Refrigeration**

Industry records show sales of more than 3 million air conditioning units in 1978 with considerable additional growth expected in the next five years. These growth factors open many new jobs each year in sales, installation and service. Salaries range from $7,500 to start, to $25,000 after 4 years experience.

**For Additional Information**

Please contact any of the following for more information about the Air Conditioning and Refrigeration Program:

Coordinator, Air Conditioning and Refrigeration
Associate Dean, Technology
Call College of DuPage, 858-2800

**The Air Conditioning and Refrigeration Program**

The student, in cooperation with his advisor, may design an individualized program emphasizing air conditioning and refrigeration courses, combined with electives from the general college curriculum and related occupational programs. Each student may structure his course schedule to meet individual needs and interests. Each student is urged to meet with the program coordinator prior to registering for any classes!

**Suggested Courses for Program Completion**

| | | |
|---|---|---|
| AC&R 100 | Intro to Controls | 3 |
| AC&R 101 | Basic Refrigeration | 3 |
| AC&R 102 | Cycle and System Components | 3 |
| AC&R 103 | Air Conditioning Systems | 3 |
| AC&R 105 | Instruments | 4 |
| AC&R 110 | Basic Control Systems | 4 |
| AC&R 161 | Intro. to Sheet Metel | 3 |
| AC&R 162 | Sheet Metal Layout and Fabrication | 3 |
| AC&R 201 | Service Procedures | 4 |
| AC&R 202 | Control Systems | 4 |
| AC&R 210 | Commercial Refrigeration | 4 |
| AC&R 220 | Installation | 4 |
| AC&R 230 | Advance Controls | 4 |
| AC&R 240 | Duct Design | 3 |

**Elective Courses**

| | | |
|---|---|---|
| AC&R 180 | Gas Heating | 3 |
| AC&R 182 | Oil Heating | 3 |
| AC&R 184 | Electric Heating | 3 |
| AC&R 186 | Piping and Accessories | 3 |

**Automotive Option**

| | | |
|---|---|---|
| AC&R 141 | Auto Air Conditioning | 3 |
| AC&R 142 | Auto Air Controls | 3 |

**Sheet Metal Option**

| | | |
|---|---|---|
| AC&R 250 | Air Distribution | 3 |
| AC&R 261 | Advanced Sheet Metal | 3 |
| AC&R 262 | Advanced Sheet Metal | 3 |
| AC&R 263 | Advanced Sheet Metal | 3 |

**Revised 12/79**

COLLEGE OF DuPAGE ◆ GLEN ELLYN ILLINOIS 60137 ◆ TELEPHONE 312-858-2800

## IMPORTANT NOTICE

There will be a meeting of the Air Conditioning Refrigeration and Heating Departments Advisory Board Committee on April 1, 1980. Please leave this date open and mark it on your calendar.

The Advisory Board is a very important part of a community college. The only way I can get input on what the community feelings are on what we are doing here at the college is through the people on my board.

If you cannot make the meeting, please send someone affiliated with you in your place. I need your input.

The agenda for the meeting will be as follows:

1) Meet at 1:00 PM at the school in room A1047 on April 1, 1980. (This is in A Building, Lower Level, far northeast corner)

2) Discuss need for new certificate development.

3) Discuss grant for development of solar installer courses.

4) Go over career ladders for student advancement.

5) Discuss need for inplant training.

6) Open for ideas and discussion.

Please reply to this notice as to whether you will attend or not. Call 858-2800, extension 2322.

Sincerely,

Gene C. Walker
Coordinator, Air Conditioning/Refrigeration

GW/mjl

College of DuPage

Glen Ellyn, Illinois

Building A - Room 1047

Advisory Board Meeting - April 1, 1980

Members Present: Louis Koley
Jack Zaruba
Bob Johnson

The meeting was called to order at 1:30 p.m.

All advisory board members were asked to attend. If they were not going to attend they were asked to send someone in their place. Total attendance was one member, one instructor and one assistant dean. This was a very depressing response. Due to this response certain assumptions were made.

All ladder steps were approved as viable by board members present.

Discussion of why no advisory quorum was present, no conclusion.

It was determined that solar will have to be forced down the throats of not only the general public but also the contractors who will install it. It is a shame that in these days of 20% interest rates and excessive fossil fuel costs a renewable energy source is struggling to establish itself as a viable answer to part of our energy crisis.

Use of combination of Gene Walker's competency based curriculum in installation of solar and Southern Illinois' development of training program for solar installation in the redevelopment of the building construction program at College of DuPage was looked on favorably by the building contractor coordinator.

Need for inplant instruction of existing employees was discussed.

Need for redevelopment of HVACS programs into small certificate specialty programs and one blanket certificate requiring heating - air conditioning - sheet metal - solar.

Meeting adjourned at 3:30 p.m.

## SUMMATIONS OF EVALUATION OF DATA COLLECTED

The following is a study of solar marketing--sales and service--in DuPage County and surrounding areas. This should summarize the need for the curriculum that was developed--the great need for understanding of solar.

## SOLAR ENERGY MARKET POTENTIAL AND PROJECTIONS

THE U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT AND U.S. DEPARTMENT OF ENERGY WAS CONTACTED. ATTACHED TO THIS REPORT IS A LIST OF BOOKS AND REPORTS THAT WILL BE USEFUL IN OBTAINING MORE INFORMATION ABOUT SOLAR MARKETING IN GENERAL.

## SOLAR HEATED TOWNHOUSE

WHAT MAY BE THE FIRST SOLAR HEATED TOWNHOUSE NEAREST THE DUPAGE AREA, IF NOT IN THE NATION, IS LOCATED IN VERNON HILL, ILLINOIS AT THE NEW CENTURY TOWN DEVELOPMENT.

BUILT BY THE UNITED DEVELOPMENT COMPANY, A SUBSIDIARY OF URBAN INVESTMENT AND DEVELOPMENT COMPANY, IT WILL BE RENTED AFTER A PUBLIC VIEWING PERIOD. TWO BEDROOM UNITS WILL RENT FOR $395 AND $410/MONTH AND THREE BEDROOM UNITS WILL RENT FOR $420 AND $435/MONTH.

THE SOLAR HEATING SYSTEM WORKS THROUGH SOLAR COLLECTORS, WHICH LOOK LIKE RACKS ON THE ROOFS OF THE TOWNHOUSES. THE SUN HEATS THE WATER INSIDE THE COLLECTORS AND THE HEAT IS TRANSMITTED TO A FORCED-AIR HEATING SYSTEM INSIDE THE HOUSE. IF THE HEAT IN THE WATER IS NOT IMMEDIATELY NEEDED, THE WATER IS STORED IN A 1,000 GALLON TANK IN THE BASEMENT.

THE SYSTEM IS DESIGNED TO PROVIDE ABOUT 60 PERCENT OF THE HOME'S HEAT AND MOST OF ITS HOT WATER IN WINTER, AND ITS AIR CONDITIONING AND COLD WATER IN SUMMER.

THE SOLAR HEATED TOWNHOUSE WILL BE OPEN DAILY FROM 10 A.M. TO 6 P.M. THE ENTRANCE TO THE MODEL HOME AREA IS NEAR HAWTHORN DRIVE AT TOWN LINE ROAD (ILLINOIS 60), 1-1/2 MILES WEST OF MILWAUKEE AVENUE (ILLINOIS 21).[1]

## SOLAR HEATING HOUSE

ONE OF THE PERSONS MOST KNOWLEDGEABLE ABOUT SOLAR HEATING SYSTEMS IN THE DUPAGE AREA IS JOHN MARTIN, AN ENERGY CONSULTANT AT ARGONNE LABORATORIES. HE ESTIMATES THAT THE SOLAR HEATING SYSTEM WILL SAVE THE FAMILY LIVING HERE BETWEEN 25 AND 33 PERCENT OF THE COST OF HEATING THE HOUSE ACCORDING TO DON DISE, A HOUSE BUILDER.

AS DISE PICTURES IT, ITS A SUNNY 30 DEGREE DAY, PERFECT FOR DINING OUT IN THE GARDEN. SO YOU DESCEND A SPACIOUS, PLANT-FILLED GARDEN, FROM ONE OF THE THREE SECOND STORY BEDROOMS. THE FOOD IS PASSED THROUGH FROM THE KITCHEN, AND YOU ARE ALL SET TO RELAX AND GAZE UP AT THE BLUE SKY IN PERFECT 72 DEGREE COMFORT. THE HEAT GENERATED BY THE SUN AND TRAPPED BY AIRTIGHT INSULATION NOT ONLY WARMS THE STUNNING GARDEN ROOM, BUT ALSO FILTERS INTO THE REST OF THE HOUSE AND EITHER REPLACES OR SUPPLEMENTS THE ELECTRIC HEAT PUMP. THAT'S HOW IT WORKS AT THE ENERGY CONSERVING SUN HOUSE THAT DON DISE IS SELLING. THE HOUSE IS EXPECTED TO SELL FOR $75,000 (1976 PRICE) BUT THE BUILDER EXPECTS TO BUILD VARIATIONS FOR $10,000 LESS.

THIS SYSTEM SEEMS MORE PRACTICAL THAN SOME OTHERS THAT ARE IN VARIOUS STAGES OF DEVELOPMENT AROUND THE COUNTRY. FOR ONE THING, ITS NOT AN EXPENSIVE ADD-ON TO THE COST OF THE HOUSE.

"WE WILL MAKE OUR USUAL MARKUP ON THE HOUSE AT THAT PRICE," DISE SAYS. "WE ARE NOT BUILDING IT AS A GIMMICK, BUT A HOUSE THAT WE EXPECT TO OFFER ON SEVERAL LOTS AT A (UNDISCLOSED) SITE IN DUPAGE COUNTY.

THE DISE HOMES ARE NOT ENCUMBERED WITH HEAT COLLECTOR EQUIPMENT, STILL IN THE EXPERIMENTAL STAGE AND THEREFORE, COSTLY TO INSTALL. SO THE HOUSE DOES NOT STORE HEAT FOR LATER USE, AS THOSE WITH COLLECTOR SYSTEMS CAN DO. IT MERELY USES THE SUN'S HEAT WHEN IT IS AVAILABLE, AND UTILIZES A HEAT PUMP AND SPECIALLY DESIGNED FIREPLACE WHEN THE WEATHER IS CLOUDY.

"THE FIREPLACE CAN BE AN IMPORTANT SUPPLEMENT TO THE SUN AND HEAT PUMP," DISE SAID. "FIREPLACES USUALLY ARE NOT EFFICIENT BECAUSE THEY LOSE MORE HEAT THAN THEY SUPPLY. BUT THIS ONE IS GLASS ENCLOSED ON THREE SIDES WITH CONTROLS FOR THE CHIMNEY THAT KEEP THE HEAT INSIDE THE HOUSE."

THE HOMEOWNER'S TWO CONCERNS WITH THIS SYSTEM ARE TO KEEP TOO MUCH SUN FROM OVERHEATING THE HOUSE IN SUMMER AND TO WORK THE 15 FOOT HIGH PLEXIGLAS SKYLIGHT.

"WE WILL HAVE REFLECTIVE SHADES THAT CLOSE OVER THE SKYLIGHT, AND THEN YOU TURN ON AN EXHAUST FAN AND CRACK THE WINDOW A BIT AND THE ROOM COOLS OFF," DISE SAID. "WE WILL ALSO ADD FANS LIKE THEY USED TO HAVE IN ICE CREAM PARLORS TO MOVE THE AIR IN SUMMER."

"CLEANING THE GLASS ON A HIGH LADDER OCCASIONALLY IS JUST THE PRICE YOU HAVE TO PAY TO HAVE A DELIGHTFUL ROOM LIKE THIS."[2]

## SOLAR HEATING IN THE DUPAGE COUNTY

AS GROWING RANKS OF SHIVERING HOMEOWNERS DISCOVERED LAST WINTER, SOLAR HEATING STILL IS NOT COMPETITIVE WITH CONVENTIONAL HEATING BY OIL OR GAS FROM A STRICT COST STANDPOINT. NEVERTHELESS, FOR SOME

EQUALLY SOBERING REASONS A FEW BUILDERS AND ARCHITECTS ARE STUDYING ITS INTRIGUING RANGE OF POSSIBILITIES. (THE ATTACHED TABLES SHOW THOSE COMPANIES IN DUPAGE THAT ARE ACTIVE IN SOLAR ENERGY.)

| | |
|---|---|
| TABLE I: | SOLAR ENERGY BUILDING AND DESIGN PROFESSIONALS IN DUPAGE |
| TABLE II: | DISTRIBUTOR OF SOLAR EQUIPMENT IN DUPAGE |
| TABLE III: | MANUFACTURERS OF SOLAR EQUIPMENT IN DUPAGE COUNTY |

FIRST OF ALL, IF HEATING OIL AND GAS PRICES CONTINUE TO RISE AS EXPECTED, IT WILL NOT BE TOO LONG BEFORE HARNESSED ENERGY FROM THE SUN MAY BE ECONOMICAL INDEED. HOWEVER, IN THE DUPAGE COUNTY NOW, SOLAR HEATING IS NOT POTENTIALLY COMPETITIVE.

A BRIEF EXPLANATION OF SOLAR HEATING IS IMPORTANT TO UNDERSTAND. "PASSIVE" VS "ACTIVE" SYSTEMS. IN THE PASSIVE SYSTEM THE SUN'S RAYS SIMPLY FLOOD THROUGH THE GLASS TO WARM INTERIOR SPACE. LITTLE OR NO PROVISIONS ARE MADE TO CONTROL AND STORE THE ENERGY. ACTIVE SYSTEMS, THROUGH THE USE OF COLLECTOR UNITS, STORAGE DEVICES AND CIRCULATION PUMPS COLLECT, STORE, AND RECIRCULATE THE CAPTURED SOLAR HEAT. NATURALLY, THE SO-CALLED ACTIVE SYSTEM ADDS A GREAT DEAL MORE EXPENSE TO BUILDING COSTS.

AFTER TALKING WITH A NUMBER OF DESIGNERS IN THE DUPAGE AREA, THE WRITER FEELS THAT THE PASSIVE SYSTEM WILL BE MORE POPULAR IN THE NEAR-TERM EFFORTS OF BUILDERS. AS FAR AS THE DESIGNERS ARE CONCERNED, THE SOLAR EQUIPMENT IS NOT YET AN ACCEPTABLE MAINTENANCE ITEM. SOLAR EQUIPMENT BREAKS DOWN TOO FREQUENTLY AND IT REQUIRES TRAINED PERSONNEL. TRAINED PERSONNEL ARE NOT READILY AVAILABLE IN THE DUPAGE AREA.

IN THE DUPAGE AREA WHERE HEATING COSTS ARE STILL UNDER $400 ANNUALLY, SOLAR HEATING IS NOT ESPECIALLY ATTRACTIVE AT PRESENT. IN OTHER AREAS IN THE UNITED STATES, WHERE IT ALREADY COSTS AS MUCH AS $2,000 ANNUALLY TO HEAT AN ALL-ELECTRIC HOUSE, A POTENTIAL 75 PERCENT SAVINGS VIA SOLAR HEATING IS INCENTIVE ENOUGH.

THE CATCH IS THE COST OF INSTALLATION FOR AN ACTIVE SYSTEM. IT IS STILL VERY EXPENSIVE. EXPERTS FIGURE AT LEAST $4,500 TO HEAT 1,000 SQUARE FEET IN A WELL INSULATED NEW HOUSE. ADD TO THIS COST A CONVENTIONAL BACK-UP HEATING SYSTEM. AND IF YOU HAVE THE MONEY, DON'T FORGET TO AMORTIZE OVER THE LONG TERM THE SYSTEM'S ENTIRE COST.

AS WE HAVE SEEN, THE PASSIVE SOLAR HEATING SYSTEM RELIES UPON THE PASSAGE OF SOLAR HEATING THROUGH SOME TRANSMITTING SURFACE. IT WORKS LIKE THIS: SHALLOW, BOX-SHAPED UNITS CONTAINING PIPES CALLED "FLAT-PLATE COLLECTORS" ARE MOUNTED ON A SURFACE (SUCH AS THE ROOF) AS NEARLY PERPENDICULAR TO THE SUN'S MAXIMUM RAYS AT NOON AS POSSIBLE. WATER OR AIR IS CIRCULATED THROUGH THE PIPES, ABSORBING HEAT FROM THE SUN AND TRANSFERRING IT TO A STORAGE UNIT, USUALLY LOCATED IN THE HOUSE'S BASEMENT. HERE THE HEAT IS STORED IN AN INSULATED TANK OF WATER OR IN A TANK FILLED WITH ROCKS, READY TO BE CIRCULATED BY WATER PIPES BACK THROUGH THE HOME. ENOUGH HEAT CAN BE STORED IN THIS WAY TO LAST FROM TWO TO FIVE CLOUDY DAYS, DEPENDING ON THE SIZE OF THE SYSTEM. SOLAR WATER HEATING SYSTEMS FOR HOUSEHOLD USE ARE SIMILAR IN CONCEPT AND OPERATION.

ACTIVE SYSTEMS ARE MORE TROUBLESOME AND COSTLY. DESIGNERS MUST WRESTLE TO HAVE THE MEANS OF KEEPING THEIR SOLAR COLLECTORS AT OPTIMUM ANGLE OF THE SUN. IN SOME AREAS, IT IS A MATTER OF ROOF PITCH; LESS FREQUENTLY, DEVICES ARE RIGGED TO AUTOMATICALLY ADJUST THE COLLECTORS FOR BETTER SUN ANGLE. NATURALLY, ANY OF THESE REFINEMENTS ADD COSTS.[3]

## SOLAR FURNACE

A DUPAGE COUNTY HOMEOWNER TODAY COULD PURCHASE A SELF-CONTAINED SOLAR FURNACE MADE BY CHAMPION HOME BULDERS COMPANY WHICH PLUGS INTO ANY FORCED-AIR HEATING SYSTEM. IF YOU INSTALL THE UNIT YOURSELF, THE BASIC COST IS $2,100 TO $3,500.

THE SOLAR FURNACE IS AN AUXILIARY FURNACE--YOU MUST KEEP YOUR EXISTING FURNACE. DEPENDING ON HOW WELL INSULATED YOUR HOUSE IS, THE SOLAR FURNACE CAN HANDLE ABOUT 50 PERCENT OF YOUR ANNUAL HEATING LOAD. GOING BEYOND THAT WOULD BE ECONOMICALLY AND TECHNICALLY UNFEASIBLE CHAMPION ADMITS. BUT A MAINTENANCE-FREE SYSTEM THAT RUNS ON A LITTLE ELECTRICITY (FOR BLOWER MOTORS) AND A LOT OF FREE SUNLIGHT COULD BE A SOUND INVESTMENT.

THE SOLAR FURNACE WHICH LOOKS LIKE AN A-FRAME GARDEN SHED, IS INSTALLED OUTSIDE YOUR HOME, FACING A CLEAR SOUTHERN EXPOSURE. BURIED INSULATED DUCTS AND ELECTRIC LINES CONNECT THE FURNACE TO YOUR EXISTING FURNACE DUCTWORK IN YOUR HOME.

ONCE ON SITE, THE FURNACE'S HEAT STORAGE CHAMBERS ARE FILLED WITH CLEAN RIVER GRAVEL ROCK, ABOUT 22,000 TO 43,000 POUNDS OF IT.

COLLECTED SUNLIGHT FROM THE A-FRAME CONVERTS TO VERY HOT AIR BENEATH THE GLASS AND IS SUCKED INTO THE CHAMBERS WHERE IT HEATS THE ROCKS. THE ROCKS RETAIN THE HEAT. A SEPARATE FAN, ACTIVATED BY A SOLID STATE HOOK-UP WITH YOUR REGULAR HOUSE THERMOSTAT WILL PULL COOL AIR FROM THE HOUSE AND THROUGH THE ROCK CHAMBERS. IF THE ROCKS ARE NOT HOT ENOUGH TO MEET THERMOSTAT DEMANDS, YOUR REGULAR FURNACE GOES ON.

CHAMPION SOLAR FURNACES ARE EIGHT FEET HIGH, EIGHT FEET AT THE BASE AND FROM 12 TO 20 FEET LONG. DEALERS MEASURE YOUR HOUSE AND DETERMINE ITS HEAT RETENTION BEFORE RECOMMENDING A UNIT.

OBVIOUSLY, A SOLAR FURNACE IS NOT PRACTICAL FOR THE TYPICAL DUPAGE HOMEOWNER.[4]

## AVAILABILITY OF SOLAR ENERGY IN THE DUPAGE COUNTY

THE AMOUNT OF SOLAR ENERGY STRIKING A SQUARE FOOT ON THE EARTH'S SURFACE VARIES THROUGHOUT THE UNITED STATES. CLIMATIC FACTORS SUCH AS TEMPERATURE, CLOUD COVER, HUMIDITY, AND WIND AFFECT THE WAYS IN WHICH SOLAR SYSTEMS ARE USEFUL. FOR THESE REASONS, THE CONTIGUOUS UNITED STATES HAS BEEN DIVIDED INTO TWELVE SOLAR CLIMATIC ZONES.

DUPAGE COUNTY FALLS INTO CATEGORY #1. FOR A 1,500 SQUARE FOOT HOUSE LOCATED IN DUPAGE, SOLAR HEATING WOULD PROVIDE 71% OF THE TOTAL LOAD.[5]

## AVAILABILITY OF MORTGAGE CREDIT

LENDERS APPEAR GENERALLY RECEPTIVE TO MORTGAGE REQUESTS ON SOLAR HOMES. FEW WILL REJECT SUCH A REQUEST OUTRIGHT WITHOUT AT LEAST HAVING FIRST CONSIDERED THE SPECIFICS OF THE PROPOSAL.

SOLAR HOT WATER SYSTEMS GIVEN THEIR LOWER FIRST COST ARE LIKELY TO BE EASIER TO FINANCE IN FULL IN THE PRIVATE MARKET TODAY THAN SPACE HEATING SYSTEMS. IN RESPECT TO SOLAR HEATED RESIDENCES, MOST BANKERS PREFER AND EXPECT THAT MORTGAGES WILL INITIALLY BE WRITTEN ON CUSTOM-BUILT FAMILY HOMES FOR RELATIVELY AFFLUENT BORROWERS.

FOR THOSE INVOLED IN THE HOUSING INDUSTRY, FOR LENDERS WHO FINANCE THEIR ACTIVITES AND NOT LEAST FOR HOME BUYER AND RENTERS, THE CONTINUED HIGH INTEREST RATES AND THE RAPID AND CONTINUING INCREASES IN OTHER COMPONENTS OF HOUSING COSTS MAY HAVE CONSIDERABLY HIGH PRIORITY THAN ENERGY ISSUES. IN OTHER WORDS, FOR SOLAR ENERGY TO HAVE AN IMPACT, PRIVATE MARKETING STRATEGIES SHOULD BE DESIGNED WITH AN EYE TO THE UNDERLYING PRIORITIES OF THOSE INVOLVED WITH HOUSING TODAY.

## SERVICE

THE CONTRACTORS THAT SELL THE EQUIPMENT WILL USUALLY PROVIDE TRAINED PERSONNEL TO SERVICE THE EQUIPMENT. HOWEVER, THE "SATURDAY HANDYMAN" WOULD NOT BE ABLE TO SERVICE THE EQUIPMENT DUE TO ITS COMPLEXITY.

## BIBLIOGRAPHY

[1] "A SOLAR HEATED TOWNHOUSE THAT WILL SOON BE FOR RENT," SUNDAY SUN-TIMES, JUNE 27, 1976.

[2] "SUNNY DAYS INSIDE A SOLAR HOUSE," JERRY DAVIS, SUN-TIMES, FEBRUARY 29, 1976.

[3] "THE TRUTH ABOUT SOLAR HEAT," GEORGE BERONIUS, SUN-TIMES, SEPTEMBER 11, 1977.

[4] "SOLAR FURNACE A WARM PROSPECT," JOHN HAHN, DAILY NEWS, AUGUST, 28, 1976.

[5] "SOLAR ENERGY FOR SPACE HEATING AND HOT WATER," ENERGY RESEARCH, MAY, 1976.

[6] "HOME MORTGAGE LENDING AND SOLAR ENERGY," U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, FEBRUARY, 1977.

## CONCLUSIONS AND RECOMMENDATIONS

### Based on the Findings of the Project Director

Through the use of training guides such as developed by this project and others, the solar industry may have a growing chance of being the major new heating system in Illinois homes and industries. It has been found that the only way to introduce solar is through approaches that show it as an additional means of heating. Solar cannot stand alone. It can be used as the primary source of heat, but must have backup. This is why the Solar Installers Guides first teach solar, with the latter part of the Guide being all backup system. The sheetmetal workers, pipefitters, plumbers, carpenters, etc., all want a part of solar. These trades will all still exist, and there will be no "Solar" union or trade that stands alone. It will be incorporated into the aforementioned existing trades.

Solar heating in residential type applications is generally done with flat-plate collectors mounted horizontally on a flat roof, tilted toward the equator. They can also be found mounted vertically along the side of the building facing the equator. Heat as it is received from the sun is transferred from the collector to a heat storage unit by a stream of circulating water or air. The storage medium after absorbing the heat returns the circulating water or air back to the collectors. A fan that circulates air through the storage unit will heat the space required. The choice of water or air as the transfer medium between collectors and storage unit require consideration depending upon the particular application.[1] Typically a 3,000 gallon tank is enclosed in an insulated box shaped heat bin. The space between the walls of the wooden bin and the tank is filled with stones. When stored heat is to be used in the house, air from inside the rooms is pumped through the heat bin, where it absorbs heat from the stones and from the outer surface of the water tank. An auxillary heating system is located along with the solar system and uses the same duct system whenever the stored solar heat is insufficient.[2]

When air is used as the circulating medium the heat is stored in salts such as hydrated sodium sulfate, that have large heats of fusion or of transition from one crystalline state to another. As with the water circulating system, stored energy is supplied to the house by circulating air from the rooms through the storage material.[3]

Water transfers heat more effectively and requires only small pipes. The air-heating system requires larger pipes and needs simpler motor driven fans than a water-heating system. Freezing weather can also be a great disadvantage to the water-heating system in addition to requirement for watertight construction.[4]

Houses with flat roofs are much easier to adapt to solar collectors, though in general houses with sloping roofs are more common in the areas where heating is important, because of the snow problem. A collector, flat or tilted, can be hidden on a flat roof but on a sloped roof it becomes as conspicuous as an outdoor advertising billboard which is in many cases undesirable.[5]

When an object is exposed to solar radiation its temperature rises until its heat losses become equal to its heat gains. The losses depend on the emission of radiation by the heated material, the movement of the surrounding air, and the thermal conductivity of the materials in contact with it. The gains depend on the intensity of solar radiation and the absorptivity of solar radiation by its surface. Solar radiation can be collected in two general ways to produce higher temperatures; by covering a receiving surface with a sunlight-transparent sheet of glass or plastic, and by focusing the solar radiation from a large area onto a receiver of small area.[6]

Solar collectors are conveniently classified as flatplate collectors, which do not focus, and as focusing collectors. The flat-plate collectors are usually stationary but are often moved every few days to follow the season; the focusing collectors are usually turned throughout the day to follow the sun. The flat-plate collectors are generally cheaper and they use heat from the diffuse solar radiation as well as from the direct radiation and can operate on bright cloudy days. The focusing collectors and use only the direct radiation but can produce much higher temperatures. In both types of collectors the receiving surface should be as black as possible, to absorb over ninety five percent of the radiation and reflect only a negligible amount.[7]

(3)

The large flat-plate solar receivers are made of sheet metal, usually iron, copper, or aluminum, to give good heat conduction. The surfaces are blackened with dull paint which often contains carbon black, or they are covered with a black coating produced chemically. The plate absorbing the radiation rises in temperature and transfers the heat to a fluid, usually air or water, flowing on the back side of the collector. At the same time the heated collector wastes heat to the surroundings by convection to moving air currents, by conduction to the air and to colder parts of the structure which holds the receiver, and by infrared radiation.[8]

The black absorbing sheet is placed in a frame usually of wood, and tilted at the proper angle. For heating water, the water pipes are attached to the back by means that insure good thermal contact. The absorbing sheet may be set airtight into a long rectangular box in such a way that there is an air duct at the back and the blackened sheet constitutes the front surface. Or the black absorber may be at the back of the receiver with a sheet of glass or plastic as the front cover. The box holding the collector is made of thin wood, plastic, or very thin metal to minimize heat losses by thermal conduction, and covered with insulation material such as glass wool or plastic foam to reduce heat losses to the surrounding air.[9]

The glass or plastic transparent cover reduces the heat losses from convection and radiation. Two or more covers are more effective than one, but each transparent covering reduces the incoming solar radiation by absorption in the glass or plastic by eight percent because of reflection at the two glass-air interfaces. When multiple transparent plates are used they are placed about one inch apart to minimize the circulation of air between plates and thus reduce the loss of heat by convection.[10] (4)

With focussing collectors it is easy to obtain much higher temperatures. The only problems are that they usually cost more and they need to be moved to track the sun and they only use the radiation that comes directly from the sun unscattered by clouds or haze. Focusing collectors in the form of parabolic mirrors can give temperatures ofup to 3500°C. Even a fairly crude parabolic collector made of aluminized plastic film lining a plastic shell can produce temperatures of 500°C and higher.[11]

Solar heat may be stored by raising the temperature of such inert substances as water or rocks. Water has about the highest heat capacity per kilogram or per liter or per dollar of any ordinary material. A liter of water raised through 20°C will return the 20kcal which it has absorbed, when it is cooled to its original temperature. Pebble rocks or rock piles have many advantages for storing of heat that is removed from a stream of warm air. The large surface area and the tortuous path through the bed ensures very rapid heat exchange.[12]

Another approach to solar heating is the use of rooftop ponds of water with movable insulating covers. The scheme can be used only in areas with dry desert climates where flat roofs are acceptable because there is no snow. The surface of the roof is blackened and covered with closed plastic bags containing water equivalent to a depth of six to eight inches over the surface. Solar energy received by the blackened surface heats the water in the bags during the sunny hours of the day. Just before sunset, insulating covers are drawn across the roof on tracks above the water bags to prevent cooling by nocturnal radiation. The warm water bags heat the ceiling of each room below and this in turn radiates to ~~the~~ rooms below. The warming effect can

(5)

also be supplemented by forced circulation of room air to the ceiling so it may absorb more heat by contact.[13]

Since about one fourth of the world's consumption of fuel is used for heating buildings, it is evident that solar energy for heating could well provide the means for conserving the world's supply of coal, oil and gas. From a technical standpoint solar house heating is easily accomplished, but from the economic and architectual standpoints there are other problems. The initial cost of the solar equipment is much greater than that of a fuel-fired system and amounts to at least $2,000.00 for a small house. The area required for the collector is a major fraction of the floor area of the building, and efforts to incorporate this large area into the south facing portions of the roof have not always been architecturally pleasing. Conbustion fuels in the U.S. and elsewhere though scarce, are still relatively inexpensive compared to the larger capital investment required for going to a solar heating system. In those regions most needful of heating the sunlight is of low intensity in the winter. The major cost of the solar alternative is in the heat collector, and the expense of enough heat storage capacity to carry a building through a week or so of cloudy weather in cold climates is excessive. Due to the major initial capital investment fo the heat collectors, the biggest barrier to rapid expansion of solar energy is the cost of the collectors. This includes both the flat-plate collectors for moderate temperature applications and the movable focusing type for the high temperature applications. There is great anticipation of wider use of solar energy with the development of plastics for collectors.[14]

In spite of difficulties the importance of saving fuel and reducing air pollution is such that there sould be a substantial increase in the use of solar house heating in the next decade. Also, someday in the not to distant future the world will hardly want to live with the political distribution of fossil fuels and even uranium deposits. Consequently, solar energy may also eventually become a political necessity.[15]

(7)

## FOOTNOTES

[1] Farrington Daniels, Direct Use Of The Sun's Energy, p 151

[2] Daniel Behrman, Solar Energy The Awakening Science.

[3] Ibid.

[4] Op.cit., Daniels.

[5] Ibid., p 159

[6] Ibid., p 50

[7] Ibid., pp 50, 51

[8] Ibid.

[9] Ibid., p 54

[10] Ibid.

[11] Ibid., p 57

[12] Ibid., pp 136, 137

[13] Op.cit., Behrman

[14] Op.cit., Daniels, pp 149, 150, 352

[15] Op.cit., Behrman, p 395

(8)

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Behrman, Daniel. Solar Energy The Awakening Science. Boston: Little Brown & Company, 1976

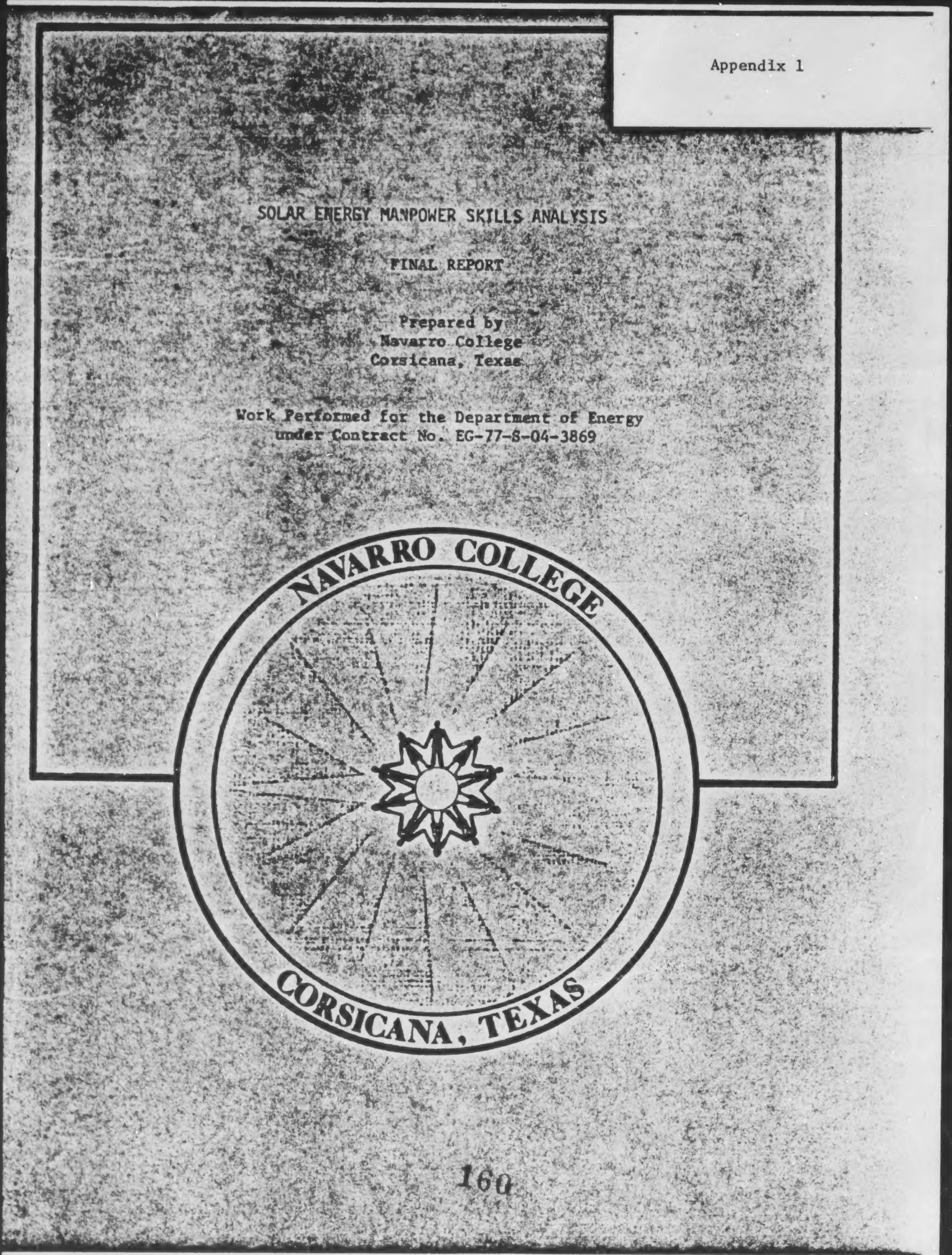
Daniels, Farrington. Direct Use Of The Sun's Energy. London: Yale University Press, 1964

# CONSULTANTS

Appendix 1 - Navarro College, Corsicana, Texas

Appendix 2 - Associated Educational Consultants, Inc.
Pittsburgh, Pennsylvania

Appendix 1



# SOLAR ENERGY MANPOWER SKILLS ANALYSIS

## FINAL REPORT

Prepared by
Navarro College
Corsicana, Texas

Work Performed for the Department of Energy
under Contract No. EG-77-S-04-3869

# INSTRUCTIONS FOR COMPLETING TASK INVENTORY FOR SOLAR ENERGY TECHNICIAN

Carefully read each task statement and answer the questions in the three columns to the right of each task statement.

Place in the first column the number of persons normally required to perform the task.

Place in the second column your best estimate of the time required (in hours and minutes) to perform the task.

Place in the third column the number 1, 2, or 3, depending on whether the task is: 1-easy to learn; 2-moderately difficult to learn; 3-very difficult to learn.

There may be task statements which you feel are not relevant to the work performed by a solar technician. In that case, leave the three columns to the right of that task statement blank.

There may be task statements omitted which you know to be relevant to the work performed by a solar technician. Extra lines have been provided for your convenience in inserting additional statements.

The Inventory is directed primarily toward application of active systems to single family residences. If your experience is in passive systems or with other than residential systems, we would appreciate your listing the steps required in the process of designing, installing, and maintaining those systems.

For purposes of this report, the type of tradesman for each task was indicated by our panel of experts. This denotation was made as to the type of tradesman who traditionally or normally would perform that task. The symbols are as follows:

C - Carpenter
E - Electrician
H - HVAC man
P - Plumber
S - Solar person
SM - Sheet metal man
X - Other (Homeowner, General Laborer, and Commercial Insulator)

For simplicity, the times given on this Task Inventory are in minutes rather than in hours and minutes as specified in the instructions.

## TASK INVENTORY

| DESIGN STAGE | No. Persons Required Type Person | Time Required (Minutes) | Learning Difficulty |
|---|---|---|---|
| Calculate Hot Water Load | | | |
| 1. Determine monthly average ground water temperature | 1 - S | 15 minutes total | 1 |
| 2. Determine design hot water temperature | 1 - S | | 1 |
| 3. Determine hot water requirement for persons | 1 - S | | 1 |
| 4. Determine hot water requirement for applicances | 1 - S | | 1 |
| 5. Determine BTU requirement of monthly hot water load | 1 - S | | 1 |
| | | | |
| | | | |
| | | | |
| | | | |
| . Calculate Space Heating Load | | | |
| 1. Determine inside and outside design temperatures and design wind speed | 1 - H | 0 | 1 |
| 2. Determine U-values for structure components | 1 - H | 60 | 2 |
| 3. Determine areas of structure components | 1 - H | 60 | 1 |
| 4. Determine infiltration of structure | 1 - H | 15 | 2 |
| 5. Calculate total heat loss under design conditions in BTU/hr | 1 - H | 15 | 1 |
| 6. Divide design heat loss by design temperature differential and multiply by 24 to obtain heat loss in BTU/DD | 1 - H | 10 | 1 |
| 7. Determine monthly heating degree days | 1 - H | 0 | 1 |
| 8. Determine degree day correction factor for outside design temperature | 1 - H | 60 | 2 |
| 9. Calculate monthly BTU requirement for space heating load | 1 - H | 5 | 1 |
| | | | |
| | | | |
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| DESIGN STAGE | No. Persons Required Type Person | Time Required (Minutes) | Learning Difficulty |
|---|---|---|---|
| C. Calculate Space Cooling Load | | | |
| 1. Determine inside and outside design temperatures, latitude, and daily temperature range | 1 - H | 10 | 1 |
| 2. Determine equivalent temperature differences | 1 - H | 15 | 1 |
| 3. Determine U-Values for structure components | 1 - H | 60 | 2 |
| 4. Determine areas of structure components | 1 - H | 60 | 1 |
| 5. Determine window shading | 1 - H | 60 | 2 |
| 6. Determine transmittance of windows | 1 - H | 0 | 1 |
| 7. Calculate heat gain through windows | 1 - H | 30 | 2 |
| 8. Calculate internal heat gains | 1 - H | 20 | 1 |
| 9. Calculate total heat gains under design conditions | 1 - H | 15 | 1 |
| 10. Divide design heat gain by design temperature differential and multiply by 24 to obtain heat loss in BTU/DD | 1 - H | 10 | 1 |
| 11. Determine monthly cooling degree days | 1 - H | 15 | 1 |
| 12. Calculate monthly BTU requirement for space cooling load | 1 - H | 5 | 1 |
| | | | |
| | | | |
| | | | |
| | | | |
| D. Choose Collector Type | | | |
| 1. Determine average operating collector fluid temperature | 1 - S | 60 | 2 |
| 2. Determine design ambient temperature and insolation | 1 - S | 10 | 1 |
| 3. Determine flat-plate and concentrating collector efficiencies for design conditions | 1 - S | 5 | 1 |
| 4. Determine cost per square foot of collector types | 1 - S | 120 | 3 |
| 5. Calculate $/BTU | 1 - S | 5 | 1 |
| 6. Choose collector type with lowest energy cost | 1 - S | 15 | 1 |

| DESIGN STAGE | No. Persons Required Type Person | Time Required (Minutes) | Learning Difficulty |
|---|---|---|---|
| . Calculate solar gain on unit area basis | | | |
| 1. Determine collector tilt for application | 1 - S | 10 | 2 |
| 2. Determine for each month average hourly insolation for tilt and latitude | 1 - S | 120 | 3 |
| 3. Determine for each month average ambient daylight temperature | 1 - S | 60 | 1 |
| 4. Determine monthly collector efficiency from collector performance curve. | 1 - S | 120 | 3 |
| 5. Determine monthly clear day collector heat gain in BTU/Ft.$^2$-hr. | 1 - S | 10 | 2 |
| 6. Determine for each month average daily daylight collection hours | 1 - S | 0 | 1 |
| 7. Determine haze factor for locality | 1 - S | 0 | 1 |
| 8. Determine average monthly percent of sunshine | 1 - S | 0 | 1 |
| 9. Calculate unit monthly solar gain in BTU/Ft.$^2$ | 1 - S | 10 | 1 |
| | | | |
| | | | |
| | | | |
| | | | |
| . Determine maximum available collector area | | | |
| 1. Determine roof space dimensions | 1 - S | 30 | 1 |
| 2. Determine ground space dimensions | 1 - S | 30 | 1 |
| 3. Eliminate shaded spaces | 1 - S | 20 | 2 |
| 4. Determine collector physical dimensions | 1 - S | 5 | 1 |
| 5. Allow for proper spacing of collectors on flat roof | 1 - S | 20 | 1 |
| 6. Allow for proper collector tilt and azimuth | 1 - S | 10 | 2 |
| 7. Calculate maximum collector area in square feet | 1 - S | 10 | 1 |
| | | | |
| | | | |

| DESIGN STAGE | No. Persons Required Type Person | Time Required (Minutes) | Learning Difficulty |
|---|---|---|---|
| . Determine optimum collector area | | | |
| 1. Multiply given collector area by monthly unit solar gain to obtain monthly solar gain in BTU | 1 - S | 10 | 1 |
| 2. Obtain monthly useful solar gain by taking the lesser of the monthly solar gain and the monthly total load. | 1 - S | 5 | 1 |
| 3. Obtain the typical annual useful solar gain in M BTU by summing the monthly totals and dividing by $10^6$ | 1 - S | 5 | 1 |
| 4. Determine the auxiliary fuel efficiency (decimal) | 1 - S | 0 | 1 |
| 5. Obtain auxiliary fuel saved by dividing the annual useful solar gain by the auxiliary fuel efficiency | 1 - S | 5 | 1 |
| 6. Determine cost of solar system | 1 - S | 90 | 2 |
| 7. Determine the mortgage interest rate and term | 1 - S | 5 | 1 |
| 8. Determine cost and inflation rate of auxiliary fuel | 1 - S | 5 | 3 |
| 9. Calculate life cycle value of solar system | 1 - S | 30 | 3 |
| 10. Iterate above steps with different collector areas to obtain maximum life cycle value | 1 - S | 180 | 3 |
| (If you are using another method, please describe) | | | |
| | | | |
| | | | |
| | | | |
| . Design fluid flow system | | | |
| 1. Determine proper storage size and location | | | |
| 2. Integrate solar and conventional systems | 1 - S | 120 | 3 |
| 3. Design system controls and operation modes | 1 - S | 60 | 3 |
| 4. Size individual system components in accordance with collector size and load requirements | 1 - S | 180 | 3 |
| 5. Prepare working drasings | 1 - S | 120 | 3 |
| 6. Prepare materials and equipment specifications | 1 - S | 120 | 3 |
| | | | |
| | | | |

| INSTALLATION | No. Persons Required Type Person | Time Required (Minutes) | Learning Difficulty |
|---|---|---|---|
| I. Construct Storage System | | | |
| 1. Prepare foundation | 2 - X | 240 | 2 |
| 2. Insulate foundation (Deleted by Experts) | | | |
| 3. Install or construct storage container shell | 2 - P | 120 | 1 |
| *4. Install internal container components | 2 - P | 180 | 2 |
| 5. Install temperature sensors | 1 - H | 60 | 2 |
| *6. Make connections to system | 2 - P | 60 | 2 |
| 7. Insulate storage container | 2 - X | 180 | 2 |
| *For Air System: | | | |
| I.4. | 2 - SM | 180 | 2 |
| I.6. | 2 - SM | 120 | 2 |
| | | | |
| J. Install collector | | | |
| 1. Prepare collector mounting foundation | 2 - C | 20 | 1 |
| 2. Construct collector mountings | 2 - C | 30 | 1 |
| 3. Mount each collector | 2 - S | 15 | 1 |
| 4. Install each temperature sensor | 1 - H | 5 | 1 |
| *5. Connect dampers, valves, safety devices as required by system design | 1 - P | 120 | 2 |
| *6. Connect manifolds and collector pipelines | 2 - P | 30 | 2 |
| *For Air System: | | | |
| J.5. | 1 - SM | 240 | 2 |
| J.6. | 2 - SM | 90 | 2 |
| | | | |
| | | | |

| INSTALLATION | No. Persons Required Type Person | Time Required (Minutes) | Learning Difficulty |
|---|---|---|---|
| K. Complete System Hookup | | | |
| * 1. Mount major solar system components: heat exchangers, air handlers, pumps, blowers, domestic hot water tanks, etc. | 2 - P | 600 | 3 |
| * 2. Connect all solar components with pipelines as required by system design | 2 - P | 480 | 1 |
| 3. Install conventional equipment (Charged to Conventional) | | | |
| 4. Make connections between solar energy components (Deleted by Experts) | | | |
| 5. Install space heating and cooling ducting (Charged to Conventional) | | | |
| 6. Install system controls and make connections to sensors | 1 - E | 240 | 3 |
| 7. Flush, fill, and purge (liquid system) | 1 - P | 240 | 2 |
| 8. Make electrical connections | 1 - E | 240 | 3 |
| *For Air System: | | | |
| K.1. | 2 - SM | 720 | 3 |
| K.2. | 2 - SM | 720 | 1 |
| | | | |
| L. System checkout | | | |
| 1. Leak test all pipelines | 1 - P | 120 | 2 |
| 2. Check out the system powered components | 1 - S | 240 | 3 |
| * 3. Insulate pipelines as necessary | 2 - P | 480 | 2 |
| 4. Calibrate and test solar temperature differential controls | 1 - S | 120 | 2 |
| 5. Test system operation modes (Deleted by Experts) | | | |
| * 6. Balance flow controls as specified | 1 - P | 60 | 2 |
| *For Air System | | | |
| L.1. | 1 - SM | 120 | 2 |
| L.3. | 2 - SM | 720 | 2 |
| | | | |
| | | | |

| MAINTENANCE (ROUTINE) | No. Persons Required Type Person | Time Required (Minutes) | Learning Difficulty |
|---|---|---|---|
| 1. Maintenance | | | |
| 1. Periodic lubrication of moving parts (pumps, blowers, etc) | 1 - X | 20 | 1 |
| 2. Filter change | 1 - X | 120 | 1 |
| 3. Clean collector glazing (Deleted by Experts) | | | |
| 4. Descale heat exchangers (water side) | 1 - P | 48 | 2 |
| 5. Flush open liquid collector loops and refill with clean solution | 2 - P | 240 | 1 |
| 6. Check drain down tank for unwanted fill (liquid drain down systems) (Deleted by Experts) | | | |
| 7. Check antifreeze solution strength and PH in liquid closed loop systems | 1 - X | 30 | 1 |
| 8. Check AP (water) thru collector loop (Deleted by Experts) | | | |
| 9. Replace sacrificial corrosion elements and other systems components which are periodically consumed | 1 - P | 15 | 1 |
| 10. Check tracking orientation of concentrating collectors | 1 - S | 240 | 3 |
| 11. Check liquid levels in expansion and storage tanks | 1 - X | 15 | 1 |
| 12. Check normal positions of motorized valves and dampers | 1 - S | 60 | 2 |
| 13. Monitor flowrates and temperature differentials to test system operation | 1 - S | 60 | 2 |
| *14. Check for degradation of pipeline insulation | 1 - P | 60 | 1 |
| 15. Check seals on pumps. | 1 - P | 5 | 1 |
| *For Air Systems | | | |
| M.14. | 1 - SM | 60 | 1 |

TASK INVENTORY

Curriculum Development
and Manpower Forecast

| | No. Persons Required Type Person | Time Required (Minutes) | Learning Difficulty |
|---|---|---|---|
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Please state in one or two paragraphs a job description of what you as an employer of a solar technician would like in an employee.

Some questions to answer might be as follows:

What skills do you require?

What is the highest level of skill you desire?

# APPENDIX L

## TASK ANALYSIS

This appendix contains the completed task analysis produced during this project.

## DESIGN STAGE

### A. CALCULATE HOT WATER LOAD

1. Determine monthly average ground water temperature.
    - a. Obtain ASHRAE Handbook or other reference, or contact water utility for temperature data. Record.
2. Determine design hot water temperature.
    - a. Determine from building plans what types of appliances (e.g. dishwasher, clothes washer) are in use, and what water temperatures they require. (Consult local code books.)
3. Determine hot water requirement for persons.
    - a. Using Uniform Solar Energy Code nomography or other reference, apply the number of persons using hot water to the graph and find total hot water consumed, or multiply number of persons by 20 gallons per day.
4. Determine hot water requirement for appliances.
    - a. Repeat above procedure for appliances using nomograph, or contact manufacturer or distributor of appliance for hot water demand.
5. Determine BTU requirement of monthly hot water load.
    - a. Read BTU requirement from nomograph, or multiply gallons used per day by the design temperature minus the supply water temperature and by 8.3 lbs. per gallon.

TOOLS AND EQUIPMENT

(A) Uniform Solar Energy Code or other reference

(B) Table of monthly average supply water temperatures (if available)

(c) Building plans

## MATERIALS AND COMPONENTS

None

## REQUIRED KNOWLEDGE

(A) Science.

- (1) Familiarity with energy units.
- (2) Ability to calculate temperature of a mass given the thermal energy added to the mass.
- (3) Knowledge of specific heats, density of water.

(B) Mathematics.

- (1) Algebra.
- (2) Graph reading.

## PERFORMANCE OBJECTIVE

Given a hot water demand situation in the form of building plans or existing building with hot water needs, the student will obtain all information necessary and perform all calculations to determine the daily hot water heating load in BTU per day, for any locality.

B. CALCULATE SPACE HEATING LOAD

1. Determine inside and outside design temperatures and design wind speed.
   a. Look up design temperatures in ASHRAE Guide or other reference, record.
2. Determine U-values for structure components.
   a. Determine ceiling, wall, floor, window, and door construction from plans or building.
   b. Find U-values for building materials used from ASHRAE Guide or other reference. If conductances are listed, multiply conductance per inch by thickness of material in inches to get U-value. Determine U-values of air films for still air and 15 MPH wind speed. Add reciprocals of U-values for each component and find reciprocal of total.
3. Determine areas of structure components.
   a. Measure dimensions of outside walls, ceilings, floors, windows, and walls using architectural scale of plan, or measure existing building to obtain this information, and record. Measure only the surfaces which represent the shell of the building.
   b. Multiply length and width to obtain area.
   c. Subtract window and door areas from gross wall areas to obtain net wall area.
   d. Sum areas of all components which have equivalent U-values.
4. Determine infiltration of structure.
   a. Multiply floor area obtained above by ceiling height to obtain volume of insulated space. Do for each room.

   b. Refer to ASHRAE Guide and multiply volumes above by appropriate factors depending on the number of walls with windows/doors exposed to the outside. (Alternately, calculate infiltration using ASHRAE "Crack" method.) Do for each room.

5. Calculate total heat loss under design conditions in BTU/hr.
   a. Subtract outdoor design temperature from indoor design temperature 70°F found in step one.
   b. Multiply the area times the U-value for each building component by the design temperature differential found in step (a), and record in tabular form. Sum these values to obtain the conduction heat-loss. For infiltration, multiply the infiltration rate values from 4.b. by .018 and be the design temperature differential and add them to the conduction heat loss to obtain the design heat loss.
6. Divide design heat loss by design temperature differential and multiply by 24 to obtain heat loss in BTU/DD.
7. Determine monthly heating degree days.
   a. Find the heating degree-days for the locality under consideration in the ASHRAE Guide or from the National Climatic Center, for each month. Record.
8. Determine degree day correction factor for outside design temperature.
   a. Refer to the ASHRAE Guide.
9. Calculate monthly BTU requirement for space heating load.
   a. Multiply the heat loss in BTU per degree-day by the number of degree-days in each month. Record the monthly heating load in BTU x $10^6$ or therms (BTU x $10^5$).

TOOLS AND EQUIPMENT

(A) ASHRAE Handbooks, Fundamentals and Systems, or other reference.

(B) Tape measure and/or architectural scale.

(C) Building plans or building

(D) Engineering note pad

(E) Calculator

MATERIALS AND COMPONENTS

None

REQUIRED KNOWLEDGE

(A) Science

(1) Knowledge of energy units

(2) Simple physics of heat transfer (conduction, convection, radiation).

(B) Mathematics

(1) Ability to convert units

(2) Algebra.

(3) Trigonometry.

PERFORMANCE OBJECTIVE

Given a building constructed of a variety of materials, the student will determine what references and information are required, will obtain them, and will calculate the design heat loss monthly heating load of the structure for any locale.

## C. CALCULATE SPACE COOLING LOAD

1. Determine inside and outside design temperatures, latitude, and daily temperature range.
    a. Using an appropriate climatic reference (ASHRAE Handbook of Fundamentals or equivalent) consult table to obtain 97½% outdoor summer design wet bulb and drybulb temperatures, and daily temperature range for the particular location.
    b. Assume an indoor summer design dry bulb temperature of 79°F and wet bulb temperature of 62°F if indoor relative humidity is to be maintained at 50%. For other desired humidity levels, determine indoor wet bulb temperature from psychometic charts corresponding to desired humidity level and interior dry bulb temperature.
    c. From a map or other geographic reference obtain the latitude of the location.
2. Determine equivalent temperature differences.
    a. Using ASHRAE Handbook of Fundamentals, determine equivalent temperature for each structural component with respect to surface orientation, outdoor design temperature (db) and daily temperature range.
3. Determine U-values for structural components.
    a. Method 1 - If U-values for winter conditions have been previously calculated, adjust those values for changes in wind velocity and direction of heat transmission according to charts and tables in ASHRAE Handbook of Fundamentals and other comparable references.

b. Method 2 - If U-values for winter conditions have not been calculated, determine thicknesses and compositions of each portion of the structure (walls, roof, etc.). Then consult an appropriate reference to determine resistance values, conductance values, or conductivity values of each structure. Perform the mathematics to convert these values to "resistances" as required. Add the resistances of each component of the structure, making adjustments for framing per Handbook of Fundamentals as required add the interior and exterior air resistance values corresponding to the direction of heat transmission, (horizontal, vertical; up or down, etc.) and wind velocity. Take the reciprocal of the sum of the resistances to obtain the U-value for the structure.

4. Determine areas of structure components.

   a. Procedure is identical to that specified in section B.3.a. for space heating load.

5. Determine window shading.

a. Horizontal overhangs

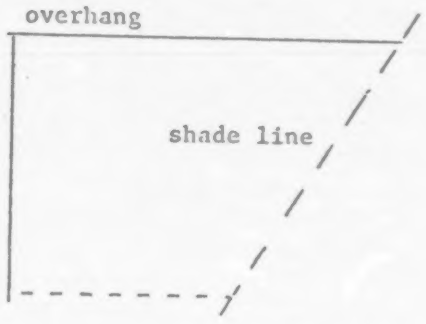
(1) Make a table of window orientations (cardinal pts.)

| N | NE | E | SE | S | SW | W | NW | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 5 a (1) |
| SHADE LINE FACTOR | | | | | | | | 5 a (2) |
| WINDOW AREAS - SHADED | | | | | | | | 5 a (5) |
| UNSHADED | | | | | | | | 5 a (6) |
| S.H.G.F. | | | | | | | | |

(2) Consult Handbook of Fundamentals and determine shade line factors for each orientation and enter into the table the corresponding orientation.

(3) Determine the length of the overhang from building plans for each orientation.

(4) Multiply result in 5 a (3) by shade line factor for each appropriate orientation to give the position of the time-averaged shade line.



(5) Determine the area for each window and orientation that is below the shade line and the area that is above the shade line. Add the results for each window of the same orientation to give a total window area that is shaded and a total window area that is unshaded. Enter the results into the table.

(6) From Handbook of Fundamentals determine a solar heat gain factor for each window orientation according to type of window construction and interior shading devices (drapes, venetial blinds, etc.).

(7) Calculate solar heat gain by multiplying solar heat gain factor for each window orientation by the unshaded window area for the corresponding orientation. Add to that the solar heat gain through the shaded areas which is calculated by multiplying the solar heat gain factor for North orientation by the sum of the shaded window areas for all orientations.

NOTE: Tasks 5.a (1) through (7) represent the accepted ASHRAE procedure for solar heat gain through fenestrations for residential structures.

8. Calculate internal heat gains.

a. Sensible heat gains.

(1) Gain due to occupants multiply # of occupants by 250 to give sensible load in BTU/hr. for occupancy.

(2) Gain due to appliances. Determine from building plans the types of appliances that will contribute to the internal heat gain of the structure (kitchen appliances epsecially). Consult Handbook of Fundamentals on other source to determine the heat gain for each appliance.

(3) Determine ventilation requirements and/or infiltration.

(a) In most cases infiltration is adequate for ventilation requirements. Assume ½ change in volume of air per hour. Calculate total volume of structure. Determine sensible gain by multiplying infiltration rate (above) by .018 x ($\Delta T_{db}$) to get infiltration gain in BTU/hr.

(b) If infiltration is not sufficient for ventilation needs (refer to Handbook of Fundamentals of other reference to make this determination within the constraints of the particular problem), determine ventilation rate in CFM. Sensible gain in BTU/hr. = (1.1) (CFM) x $\Delta t_{db}$

b. Latent heat gains. For residential method, calculate total latent gain from total sensible gain for the structure (step 9).

9. Calculate total heat gains under design conditions.

a. Sum individual sensible gains for each structure. Multiply sum by .3 to give latent gain for residential structures. (Check ASHRAE Handbook of Fundamentals to determine whether this method of calculating latent gain applies. If not, calculate latent gains independently.

b. Total heat gain is sum of latent and sensible gains.

10. Multiply total heat gain BTU/hr. by $\Delta t_{db}$ design and 24 to obtain gain in BTU/DD.

11. Calculate monthly cooling degree days.

a. Using publication 81 of N.O.A.A. (Nat. Oceanic and Atmospheric Administration) MONTHLY NORMALS OF TEMPERATURE, PRECIPATION

(3) Determine ventilation requirements and/or infiltration.

(a) In most cases infiltration is adequate for ventilation requirements. Assume ½ change in volume of air per hour. Calculate total volume of structure. Determine sensible gain by multiplying infiltration rate (above) by .018 x ($\Delta T_{db}$) to get infiltration gain in BTU/hr.

(b) If infiltration is not sufficient for ventilation needs (refer to Handbook of Fundamentals of other reference to make this determination within the constraints of the particular problem), determine ventilation rate in CFM. Sensible gain in BTU/hr. = (1.1) (CFM) x $\Delta t_{db}$

b. Latent heat gains. For residential method, calculate total latent gain from total sensible gain for the structure (step 9).

9. Calculate total heat gains under design conditions.

a. Sum individual sensible gains for each structure. Multiply sum by .3 to give latent gain for residential structures. (Check ASHRAE Handbook of Fundamentals to determine whether this method of calculating latent gain applies. If not, calculate latent gains independently.

b. Total heat gain is sum of latent and sensible gains.

10. Multiply total heat gain BTU/hr. by $\Delta t_{db}$ design and 24 to obtain gain in BTU/DD.

11. Calculate monthly cooling degree days.

a. Using publication 81 of N.O.A.A. (Nat. Oceanic and Atmospheric Administration) MONTHLY NORMALS OF TEMPERATURE, PRECIPITATION

AND HEATING AND COOLING DEGREE DAYS, determine monthly cooling degree days for the particular location.

12. Calculate monthly BTU requirement for space cooling load by multiplying results of C.10, i.e. (BTU/DD), by monthly cooling degree days to give monthly space cooling load.
    a. Determining size of components; From total cooling load, total sensible load and total latent load at interior and exterior design conditions (w.b. & d.b. temperatures) consult manufacturers data on cooling units to determine required capacity of unit

TOOLS AND EQUIPMENT

(A) Calculator with scientific functions.

(B) Reference materials: HVAC manual or ASHRAE publications; Architectural Graphics Standards or equivalent to interpret architectural drawings; degree-day data and temperature data - publications available from N.O.A.A. et.al.

(C) Architects Rule.

(D) Data Pads.

REQUIRED KNOWLEDGE

(A) Science
    (1) Fluid mechanics
    (2) Thermodynamics
    (3) Library research skills
(B) Mathematics
    (1) Algebra
    (2) Trigonometry
    (3) Calculator skills

PERFORMANCE OBJECTIVE

Given a set of architectural drawings (floor plans, elevations, structural and mechanical details), for a residence which shows site orientation, necessary reference materials including ASHRAE Handbook of Fundamentals, summer design temperature and cooling degree data, architects rule and scientific calculator, the student will perform all the necessary measurements and calculations to determine the sensible and latent cooling load of the building.

## D. CHOOSE COLLECTOR TYPE

1. Determine average operating collector fluid temperature.
   - a. Obtain manufacturers specifications on collector performance.
   - b. From collector manufacturers' specs obtain average operating collector fluid temperature that corresponds to design demands for temperature out of collector.
   - c. Enter this temperature on worksheet.
2. Determine design ambient temperature and insolation.
   - a. Obtain ASHRAE Handbook of Fundamentals or other source of meteorological and insolation data.
   - b. Look up for design month the ambient temperature and insolation values.
   - c. Enter values on worksheet.
3. Determine flat-plate and concentrating collector efficiencies for design conditions.
   - a. Obtain manufacturer's specifications for collector performance
   - b. Read design conditions from worksheet.
   - c. Enter performance graph on bottom axis at point defined by

$$\frac{T_{in} - T_{ambient}}{\text{Insolation}}$$

and go up to curve then horizontally to vertical axis and read collector efficiency.

   - d. Enter results on worksheet.

4. Determine cost per square foot of collector types.
   a. Obtain collector cost from manufacturers or sales outlet.
   b. Obtain effective solar absorber area from manufacturers literature.
   c. Divide cost of total collector by effective solar absorber area to get $\$/ft^2$ collector.
   d. Enter results in worksheet.
5. Calculate $/BTU.
   a. From D.3 above enter collector efficiency and design insolation in equation below

$$\frac{\$}{\text{BTU}} = \frac{\text{Cost/Effective Area}}{\text{Insolation x Efficiency}}$$

   b. From D.4 above enter collector cost per square foot of absorber area in equation above.
   c. Solve equation for $\frac{\$}{\text{BTU}}$
   d. Enter results in worksheet.
6. Choose collector type with lowest energy cost.
   a. From list of $/BTU in D.5 above choose collector with lowest $/BTU value.

### TOOLS AND EQUIPMENT

(A) Manufacturers performance specifications (graph)

(B) Pen or pencils

(C) Paper (worksheet)

(D) *ASHRAE Handbook* or other source of local meteorological and insolation data.

(E) Pocket calculator.

(F) Manufacturers price sheets.

## MATERIALS AND COMPONENTS

None

## REQUIRED KNOWLEDGE

(A) Science

- (1) Basic heat transfer theory
- (2) Temperature effect on properties of materials
- (3) Basic sun-earth relationship (astronomy)
- (4) Meaning of temperature, effective area, efficiency, insolation.

(B) Mathematics

- (1) Arithmetic.
- (2) Algebra.
- (3) Graph reading.
- (4) Data chart reading.
- (5) Concepts of area, price, lower versus higher value.

## PERFORMANCE OBJECTIVE

Given manufacturers' specifications and local climatological data, the student will make the proper calculations and choose the type of collector best suited to the needs of the application.

## E. CALCULATE SOLAR GAIN ON UNIT AREA BASIS

1. Determine collector tilt for application.
    a. Find local latitude from maps or atlas.
    b. Determine solar application from client or blueprints and specifications as to whether it is space heating only, water heating only, or both space heating plus water heating.
    c. If space heating only, a thumb rule for collector tilt plus 15 degrees will be appropriate to make use of the winter sun's position in the sky.
    d. If water heating only, a thumb rule for collector tilt equal to the latitude will allow year round use of collector.
    e. If combination of space heating and water heating is required, then the tilt is the same as that of space heating only.
    f. Enter results in worksheet.
2. Determine for each month average hourly insolation for tilt and latitude.
    a. Obtain ASHRAE insolation tables.
    b. Obtain local latitude and tilt from E.1. above.
    c. Enter ASHRAE tables for local latitude or closest latitude for which there is a table in the month of January.
    d. Read across to tilt closest to that determined in E.1. above.
    e. Enter in worksheet the hourly values for insolation.
3. Determine for each month average ambient daylight temperature.
    a. Obtain ASHRAE Handbook or other source of temperature data.
    b. Enter table for geographic location and list average daily daylight temperature.

4. Determine monthly collector efficiency from collector performance curve.
   a. Obtain manufacturers efficiency curves.
   b. Using the following equation

$$x = \frac{T_{in} - T_{ambient}}{I_{design}}$$

   determine "x" value using design insolation, collector design inlet temperature, and ambient temperature.
   c. Enter manufacturer's efficiency curves on horizontal axis at "x", move vertically to curve, then horizontally to vertical axis and read collector efficiency.
   d. Follow above procedure for each month of the year.
5. Determine monthly clear day collector heat gain in BTU/Ft.$^2$ -hr.
   a. From E.2. above sum all hourly insolation values greater than $\frac{125 \text{ BTU/hr}}{\text{ft.}^2}$
   b. Multiply daily clear day insolation (above) by collector efficiency from E.4. above.
6. Determine for each month average daily daylight collection hours.
   a. Obtain ASHRAE Handbook.
   b. Enter tables for closest latitudes and read number of daily daylight hours.
7. Determine haze factor for locality.
   a. Obtain local meteorological data from colleges, airports, Federal Government, or State Government, etc.
   b. Look up haze factor for locality.

8. Determine average monthly percent of sunshine.

   a. Subtract haze factor % from 100% to obtain % sunshine.

9. Calculate unit monthly solar gain in BTU/Ft.$^2$, using information obtained in above steps.

TOOLS AND EQUIPMENT

(A) Maps, Atlas, etc.
(B) Blueprints or specifications
(C) ASHRAE Handbook or other data source
(D) Pocket calculator
(E) Source of local meteorological data
(F) Pen or pencils
(G) Paper (worksheet)

MATERIALS AND COMPONENTS

None

REQUIRED KNOWLEDGE

(A) Science
   (1) Geography
   (2) Sun/earth relationships
   (3) Astronomy
   (4) Meaning of temperature, efficiency, insolation
   (5) Basic heat transfer theory
   (6) Percentages

PERFORMANCE OBJECTIVE

Given the local climatological data and the manufacturer's specifications, the student will calculate the solar gain on a unit area basis.

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## F. DETERMINE MAXIMUM AVAILABLE COLLECTOR AREA

1. Determine roof space dimensions.
   a. Obtain blueprints or drawings (to scale) of building.
   b. Using engineers or architects scale or actual on site measurement with tape measure, measure all areas of roof that give good southern exposure.
   c. Enter this area on worksheet.
2. Determine ground space dimensions.
   a. Obtain tape measure.
   b. At the site, measure length and width of ground space available for storage tank or collector placement.
   c. Enter area on worksheet.
3. Determine shaded spaces.
   a. Obtain sun angle locator box.
   b. Positioning yourself so that you are eye level with the bottom of the proposed collector array, use sun angle locator box, positioned parallel with long axis of roof, to find time of year and position of shade devices.
   c. Mark areas that will be shaded on roof/ground diagram.
   d. Measure these areas.
4. Determine collector physical dimensions.
   a. Look up dimensions on manufacturer's specification sheet.
5. Allow for proper spacing of collectors on flat roof.
   a. Obtain ASHRAE Handbook.
   b. Look up solar altitude at 10:00 a.m. on December 21.
   c. On separate sheet of paper draw to scale, side view of collector array with proper tilt and collector height.

d. Using protractor, find the point on the north side of collectors where a line drawn at an angle equal to the altitude would just touch the upper edge of the collector.

e. Measure the distance from the back of the collector array to this point with architects or engineers scale.

6. Allow for proper collector tilt and azimuth.

7. Calculate maximum possible collector area in square feet.

a. Subtract from gross area those areas that were not usable.

TOOLS AND EQUIPMENT

(A) ASHRAE Handbook.

(B) Protractor.

(C) Scales.

(D) Tape measure.

(E) Architect's or Engineer's scale.

(F) Sun angle locator.

MATERIALS AND COMPONENTS

None.

REQUIRED KNOWLEDGE

(A) Science.

- (1) Sun/earth relationships.
- (2) Astronomy.

(B) Mathematics.

- (1) Measuring skills.
- (2) Algebra.
- (3) Arithmetic.
- (4) Trigonometry.

## PERFORMANCE OBJECTIVE

Given blueprints or existing house and plot dimensions, the student will calculate the usable area for collector placement.

G. DETERMINE OPTIMUM COLLECTOR AREA

1. Multiply given collector area by monthly unit solar gain to obtain monthly solar gain in BTU.
   a. Obtain collector area from F.7.above.
   b. Obtain monthly unit solar gain from E.9.
   c. Multiply these numbers together.
2. Obtain monthly useful solar gain by taking the lesser of the monthly solar gain and the monthly total load.
   a. By looking at a column of monthly useful solar gain and a column of monthly total load enter the lesser of the two numbers for each month in a third column.
3. Obtain the typical annual useful solar gain in M BTU by summing the monthly totals and dividing by $10^6$.
   a. Add all the numbers in the third column in G.2. above.
   b. Divide this number by $10^6$ to obtain M BTU.
4. Determine auxiliary fuel efficiency.
   a. Obtain written data on fuel efficiency if possible.
5. Obtain auxiliary fuel efficiency.
   a. Multiply value in G.4. above by annual useful solar gain.
6. Determine cost of solar system.
   a. Obtain collector cost information from manufacturers.
   b. Multiply collector cost by the number of collectors to get solar collector costs.
7. Determine the mortage interest rate and term.
   a. Obtain list of mortage rates from local building institution.
   b. From this list determine mortgage rate based on system cost and lifetime.

8. Determine cost and inflation rate of auxiliary fuel.
   a. Obtain list or table of local utility rates.
   b. From this table determine rate which applies to the specific application (residential, commercial, etc.)
   c. Obtain from local Public Utilities Commission estimates for fuel inflation rates.
   d. From this information determine which rate applied.
9. Calculate life cycle value of solar system.
   a. Enter data collected above in following formula:

$$\$ = \text{Capital cost of solar system}$$

$$\$ = \left[\begin{array}{l}\text{Capital cost of solar system}\\ \text{including tax incentives or}\\ \text{other factors as reflected}\\ \text{in \$/BTU}\end{array}\right] + \left[\begin{array}{l}\text{present value of fuel}\\ \text{cost over lifetime of}\\ \text{system}\end{array}\right] + \left[\begin{array}{l}\text{present value of stream of}\\ \text{maintenance costs over life-}\\ \text{time of system}\end{array}\right]$$

10. Iterate above steps with different collector areas to obtain maximum life cycle value.

TOOLS AND EQUIPMENT

(A) Pocket calculator.
(B) Mortgage rate table.
(C) Utility rate schedules.

## H. DESIGN FLUID FLOW SYSTEM

1. Determine proper storage size and location.

    a. Locate outside tank in area protected from the elements.

    Locate inside tank in mech room insulated from conditioned space if used in summer.

    b. Determine application BTU/Hr design load requirements from A, B, & C as applicable.

    c. Determine hours of storage required for application, typically 24 hours for heating and hot water and three to four hours for cooling.

    d. Determine BTU storage requirement by multiplying hours of storage by BTU/Hr requirement.

    e. Determine design maximum storage temperature and minimum useful storage temperature.

    f. Divide BTU by the difference between maximum and minimum temperatures and divide the result by 8.33 to obtain storage size in gallons.

$$GAL = \frac{BTU}{8.33 \times \Delta T}$$

2. Integrate solar and conventional systems.

    a. For air systems, determine proper location of solar duct tie-ins. For liquid systems, determine location of water coil in conventional ductwork.

3. Design system controls and operation modes.

    a. Use two stage thermostat to bring on solar first and conventional equipment second.

    b. Use temperature sensors and relays to prevent the circulation of the solar working fluid to the load when the fluid is not hot enough to help meet the load.

c. Use a differential control and sensors to ensure that the solar collectors recharge storage and do not degrade it.

d. Use a motorized valve or check valve to ensure that storage is not degraded by thermal siphoning backflow.

e. Include relief valves, air vents, vacuum breakers, and tempering valves as necessary.

4. Size individual system components in accordance with collector size and load requirements.

   a. Determine CFM and GPM for conventional equipment and solar collectors.

   b. For liquid systems, choose water coil that meets BTU/hr load requirements at design minimum useful solar supply water temperature.

   c. For air systems, choose air to water exchanger to meet domestic hot water requirements at collector design CFM and outlet temperatures.

   d. For liquid systems requiring a water to water heat exchanger between the collector and storage, determine collector fluid specific heat, GPM, and outlet temperature; and determine tank minimum flow over the exchanger surface and design inlet temperature. Refer to manufacturer for exchanger size.

   e. Design duct and pipe sizes for required CFM and GPM not exceeding friction loss and velocity limits specified in ASHRAE handbook.

   f. Choose the smallest pump and fan models that exceed or equal design CFM and GPM at required static pressure and head.

5. Prepare working drawings.

   a. Determine schematic representation of system components: pipelines, valves, dampers, fans, pumps, storage, collectors, conventional equipment, etc.

   b. Draw wiring diagrams linking thermostats, relays, temperature sensors, and mechanical system components.

   c. Use building plans to determine physical location of components.

6. Prepare materials and equipment specifications.
   a. Determine lengths of various duct and pipe sizes needed.
   b. Determine number and sizes of elbows, tees, gate valves, manual dampers, registers, and other small passive fittings for pipeline connections.
   c. Determine number and sizes of motorized valves and dampers, pumps, fans, differential controls, thermostats, relays, relief valves, vacuum breakers, air vents, expansion and compression tanks, aquastats, and other small active system components.
   d. Determine number and model of collectors, furnaces, air conditioning units, storage tanks, or other large system equipment.

TOOLS AND EQUIPMENT

(A) ASHRAE Handbook or other HVAC manual

(B) Handbook of Physics and Chemistry or other source of physical property.

(C) Calculator

(D) Manufacturers' component specifications.

(E) Unit Conversion Tables.

(F) Note pad.

(G) Building plans.

(H) Architects Rule.

(I) Drafting equipment.

MATERIALS AND COMPONENTS

None

## REQUIRED KNOWLEDGE

- (A) Science.
    - (1) Basic heat transfer theory.
        - (a) Meaning of temperature.
        - (b) Specific heat.
        - (c) Heat exchanger equations.
    - (2) Fluid flow theory.
        - (a) Pipe sizing.
        - (b) Duct sizing.
    - (3) Understanding of pump and fan characteristics.
    - (4) Low voltage control theory
        - (a) General Principles
        - (b) Component characteristics, e.g. thermostats, relays, temperature sensors.
    - (5) Basic Electric Circuit theory.
- (B) Mathematics.
    - (1) Graph and table reading.
    - (2) Arithmetic.
    - (3) Algebra.
    - (4) Understanding of units conversion.

## PERFORMANCE OBJECTIVE

Given the building plans, thermal loads, and solar collector size, the student will design an energy collection and delivery system that provides adequate solar storage, efficient heat transfer, safe operation, and adequate auxiliary equipment to meet design loads.

## I. CONSTRUCT STORAGE SYSTEM.

1. Prepare foundation.

    a. Locate site for storage container. If container is to be above grade, clear and level ground. If container is to be buried, excavate hole for storage tank, leaving enough room to inspect tank for leaks and for insulation.

    b. For above grade tanks, determine size and method of mounting of tank and mark off approximate dimensions, or refer to plans for foundation dimensions.

    c. Excavate footing of foundation (if required by plans or local codes).

    d. Set stakes at corners of foundation and set up strings to mark of foundation, check square of foundation by measuring diagonals Adjust string lines so that the foundation is of the proper dimensions and squared.

    e. Cut form boards to coincide with string line dimensions and firmly nail corners. Set stakes around perimeter of forms. Raise form to desired level at one corner and nail to stake. Nail remainder of stakes to form, checking with level to insure the entire form is at the same level as the first corner nailed. Drive stakes at an angle (sway brace) and with inside of form lined up with string, nail stake to form. Remove string.

    f. Lay down wire reinforcing mesh if required.

    g. Pour concrete into form, spreading with flat shovel or concrete rake. Remove excess concrete by sliding 2 x 4 "rod" along tops of forms. tamp concrete with tamping device such as "jitterbug". Level and fill in holes with float. Set foundation bolts (if required to secure wall plates or tank cradle). Allow concrete to set slightly and trowel with hand trowel and/or "fresno". Hand trowel to achieve finished surface.

h. After concrete has set, strip forms and remove stakes.

2. Deleted by experts.

3. Install or construct storage container shell.

   a. (NOTE: It is assumed the technician will not construct the storage container, but will install a prefabricated system. There are a diversity of ways to construct storage systems for air and water systems which would require extremely lengthy discussions.) Unload storage container from delivery vehicle. If fork-lift or crane is required, insure that the tank or storage device is not subject to damage at the lifting points.

   b. Using manpower, forklift, or crane, set storage device on foundation or other prepared mounting, or in excavated hole. Bolt or otherwise secure.

4. Deleted by experts.

5. Deleted by experts.

6. Make connections to system.

   a. Insert threaded nipples into tank fittings (if required, applying pipe joint compound to male threads. Thread dielectric unions onto nipples (if required) and tighten with pipe wrench. (Disregard if air system.)

   b. Assemble fittings of proper size and type required to make connection between tank and plumbing stub-outs, (or duct fittings). Cut pipe or duct to appropriate lengths.

   c. Assemble fittings and pipe and double-check pipe lengths. Apply flux to cleaned pipe and fittings, re-assemble, and solder joints. (Remove rubber or plastic parts of fittings before soldering to prevent damage.) For air systems, connect duct to collars on storage tank and tape seams with duct tape.

7. Insulate storage container.

   a. Wrap tank with fiberglass, or spray tank with foaming equipment, or laminate board insulation to tank with contact cement.

   b. If tank is to be exposed to moisture or ultraviolet radiation, wrap fiberglass insulation with plastic material and secure by banding or heat sealing, or paint foam insulation with latex sealant.

TOOLS AND EQUIPMENT

(A) Shovel, pick, backhoe, trencher.

(B) Wooden or metal stakes.

(C) Tape measure.

(D) Nylon string.

(E) Circular saw.

(F) Level, hammer, nail puller, square.

(G) Wire cutters.

(H) Concrete rake, "jitterbug", "fresno".

(I) Hand float, bull float, hand trowel.

(J) Wrench set.

(K) Fort lift, crane.

(L) Screw driver, crescent wrench, pipe wrench.

(M) Propane torch, striker.

(N) Tubing cutter.

(O) Wire strippers.

(P) Paint brush.

(Q) Banding tool.

(R) Foam gun.

(S) Utility knife.

## MATERIALS AND COMPONENTS

- (A) Storage container.
- (B) Nails, bolts, screws.
- (C) Wire mesh.
- (D) Concrete.
- (E) 2 x 4 lumber.
- (F) Epoxy or thermal glue.
- (G) Clamps.
- (H) Pipe joint compound.
- (I) Thermostat wire.
- (J) Wire nuts.
- (K) Conduit.
- (L) Pipe and fittings.
- (M) Flux, emergy cloth.
- (N) Duct tape.
- (O) Insulating material(foam, board, or batt).
- (P) Contact cement.
- (Q) Plastic film.
- (R) Latex sealant.
- (S) Aspirator.

## REQUIRED KNOWLEDGE

- (A) Science

  None

- (B) Mathematics
  - (1) Arithmetic

## PERFORMANCE OBJECTIVE

Given a storage tank, or rock storage bin, or other solar thermal storage device, the student will make the necessary preparations for the installation of the storage device. He will also recognize the method of making connections to the storage device with the help of system schematics, and will make these connections, including plumbing, ducting, and control sensors. He will be familiar with the different types of insulation, and with the proper equipment, will apply the insulation in a professional manner.

## J. INSTALL COLLECTOR

1. Prepare collector mounting foundation.
    a. Mark points on roof where collector mounts are to be placed.
    b. Clean area of all loose roofing materials.
    c. Drill holes into roofing joints through roof.
    d. Lay in flashing material or roofing mastic/tar or both according to plans.
    e. Put collector mounting foundation in place and flash around it.
2. Construct collector mountings.
    a. Obtain blueprints or plans of collector mountings.
    b. Obtain material needed per plan (assess here wood mountings).
    c. Attach vertical supports to foundation.
    d. Attach angled supports (angle = tilt) to foundation.
    e. Attach angled supports to vertical supports.
    f. Attach all vertical supports together with wood members (2 x 4)
    g. Paint mountings.
3. Mount each collector.
    a. Obtain collectors from manufacturer.
    b. Raise collector onto roof.
    c. Place collector on mounting being careful not to damage copper heads or mountings.
    d. Fasten collector to mounting per blueprints.
4. Install each temperature sensor.
    a. Obtain thermistor or other sensing device per plan.
    b. If well type temperature sensor is used, insert probe in temperature well, being careful not to damage probe.

c. If strap-on type probe is used, attach probe to collector pipe storage tank with tape or mechanical clamps insuring that sensing points are fimly touching area to be measured.

*5. Connect dampers, valves, safety devices as required by system design.

a. Obtain necessary materials (i.e. air vents, relief valves, etc.)

b. Determine placement of air vents at all high points in system or per blueprints.

c. Determine relief valve placement at hottest point in system.

d. Using 3/4" copper FPT adapter, install air vents and relief valves using teflon tape on threads.

6. Connect manifolds and collector pipelines.

a. Obtain blueprint and material, i.e. pipe. elbows, couplings, etc.

b. Measure distances between collector.

c. Cut pipe length accordingly.

d. Clean and flux pipe (copper).

e. Connect pipe between collector.

f. Solder pipe fittings.

g. Insure that pipe lines are sloped such that air vents are at high points.

*Note: J.5. and J.6 should be done at the same time at least for hydronic systems.

## TOOLS AND EQUIPMENT

- (A) Blueprints or plans.
- (B) Wire brush.
- (C) Electric drill and bits
- (D) Extension cords.
- (E) Tape measure.
- (F) Hammer, framing square.
- (G) Paint brushes.
- (H) Chair hoist or other lifting apparatus.
- (I) Screw driver, pipe wrench.
- (J) Knife, level, pipe cutter.
- (K) Propane torch.
- (L) Flux brush.

## MATERIALS AND COMPONENTS

- (A) Flashing material
- (B) Redwood 4 x 4's.
- (C) Steel angle.
- (D) Brushes.
- (E) Wood fasteners.
- (F) Nails.
- (G) Lumber (2 x 4), (2 x 6).
- (H) Paint and primer.
- (I) Thermistors or thermocouples.
- (J) Tape.
- (K) Solar collectors.
- (L) Collector hold down fasteners.
- (M) Air vents, relief valves.
- (N) Pipe, fittings and adapters.

- (O) Teflon tape.
- (P) Solder, flux.

REQUIRED KNOWLEDGE

- (A) Science
  - (1) Building construction.
  - (2) Properties of metal and wood.
  - (3) Wood preservation.
  - (4) Meteorology.
  - (5) Mechanical advantage.
  - (6) Basic heat transfer theory.
  - (7) Basic electrical theory.
  - (8) Basic fluid flow theory.
  - (9) Corrosion processes.
  - (10) Basic plumbing theory.
- (B) Mathematics.
  - (1) Arithmetic.
  - (2) Basic measuring skills.
  - (3) Trigonometry.

PERFORMANCE OBJECTIVE

Given the proper tools and components, the student will install a collector array in such a way that is meets appropriate codes and standards and is done in a workmanlike manner.

K. COMPLETE SYSTEM HOOKUP

1. Mount major solar system components: heat exchangers, air handlers, pumps, blowers, domestic hot water tanks, etc.
   - a. Select location for air handler.
   - b. Construct plenum of wood or sheet metal for return air to match dimensions of air handler, or mount return air box (sheet metal) and attach collar. Install return air grill. Insulate plenum.
   - c. Place or suspend air handler. If suspended, hang with sheet metal straps. If installed vertically, fasten down with screws over return air plenum.
   - d. Install pumps. If 1/12 H.P. or under, support with plumbing, insuring plumbing is well anchored. If greater than 1/12 H.P., nail mounting block to suitable wall, etc. and fasten pump to block with lag or machine screws. Use dielectric unions where cast iron pump is connected to copper lines.
   - e. Set domestic water heater tanks in place. If tank is placed on upper story, install sheet metal drip pan underneath.
2. Connect all solar components with pipelines as required by system design.
   - a. Connect return air box (if used) to return air plenum with suitable duct material. Also connect supply air plenum to supply boxes (boots), using Y's and appropriate sized duct. Tape all joints and insulate if not using pre-insulated duct. Set supply air registers.
3. Install conventional equipment.
   - a. (Breakdown of tasks omitted since task is for non-solar equipment.)

4. Deleted by experts.

5. Install space heating and cooling ducting. (See 2.a.)

6. Install system controls and make connections to sensors.

   a. Fasten controls to wall or other location.

   b. Connect thermostat wire from sensors to terminal strip or to control leads with wire nuts (previously described).

   c. Connect all relays, thermostats, in manner described above.

7. Flush, fill, and purge (liquid system).

   a. Fill system in manner prescribed by plans.

   b. Check all pumps to insure that they are circulating water and not cavitating as a result of air in the water lines. Bleed off air through air bleeds or by loosening fittings.

   c. Turn pumps on and off several times to insure system is free of air and that pumps are not cavitating.

8. Make electrical connections.

   a. Attach conduit to control box and to junction box (if required).

   b. Feed wire (of proper gauge) through conduit.

   c. Connect leads in junction box (insure power is off) using wire nuts. Also connect leads at control to terminal strip or to appropriate leads.

   d. Secure covers to junction box and control box.

   TOOLS AND EQUIPMENT

      (A) Complete tool kit including wrenches, screw drivers, nut drivers, wire strippers, sheet metal shears, and pliars.

      (B) Propane torch and soldering apparatus, tubing cutters.

(C) VOM.

(D) Conduit tubing bender.

(E) Hack saw and high speed drill with bits.

MATERIALS AND COMPONENTS

(A) Heat exchangers, air handlers, pumps, blowers, domestic hot water tanks, etc.

(B) Copper pipe and fittings.

(C) Duct and duct fittings.

(D) Thermostat and high voltage wire, wire nuts.

(E) Hose

REQUIRED KNOWLEDGE

(A) Science.
    (1) Physics.
    (2) Electricity.

(B) Math.
    (1) Measuring skills.
    (2) Simple algebra.

PERFORMANCE OBJECTIVE

Given the system components to be installed, a system schematic and wiring diagrams, the student will, using the proper tools, mount all system components, and make plumbing, electrical, and other connections to the components. He will fill the system and insure that the system is entirely ready to be placed into operation. During the wiring phase, he will safeguard himself and others against electrical shock and insure his connections will not create a fire hazard, or cause damage to system components.

## L. SYSTEM CHECKOUT

1. Leak test all pipelines.
   a. Inspect all joints in piping for moisture.
   b. Drain and solder any faulty joints.
2. Check out the system powered components.
   a. Insure power is delivered to system components.
   b. Place system in all possible operating modes by manually switching control and/or shorting sensor wires.
   c. Check operation of pumps, automatic valves and other components in all modes to insure their operation complies with the intended mode of operation.
   d. Return control overrides to normal position.
3. Insulate pipelines as necessary.
   a. Apply pipe insulation according to method appropriate to insulation being used (hot water pipe only).
   b. Cover, tape, or seal any insulation exposed to weather.
4. Calibrate and test solar temperature differential controls.
   a. If control system is factory calibrated, inspect operation of system under various temperature and insolation conditions. Insure that system is operating in proper modes.
   b. If control is not factory calibrated, test by immersing sensors in water at various temperatures. Monitor water temperature with thermometer and check differential on and off temperatures and high or low limit functions. Use VOM to check position of relays.

5. Test system operation modes.

   a. Observe system operation under different temperature and insolation conditions. Use overrides where necessary to simulate operation conditions.

   b. Check position of all valves and operation of pumps and relays in all modes.

6. Balance flow controls as specified.

   a. Using flow meters or collector temperature monitors, adjust flow controls to achieve balanced flow rate or uniform temperature at all collectors.

   b. Flow control valves should be wide open and then gradually closed to achieve proper balance and flow rate.

TOOLS AND EQUIPMENT

(A) Utility knife.

(B) Plumbing equipment (torch, solder, pipe wrench, etc.)

(C) Complete tool kit.

(D) Flow meters.

(E) Thermometers (electronic) and VOM.

MATERIALS AND COMPONENTS

(A) Pipe insulation, jacketing, sealant.

(B) Test leads.

REQUIRED KNOWLEDGE

(A) Science:

   (1) Basic electrical circuitry.

   (2) Basic fluid mechanics.

   (3) Basic heat transfer theory.

   (4) Basic control theory.

(B) Mathematics

  (1) Arithmetic

  (2) Algebra

  (3) Basic measuring skills

PERFORMANCE OBJECTIVE

Given test equipment, system schematics, and other tools, the student will determine that the system is operating as intended and will correct or make adjustments on the system such that it does operate correctly, or determines what components are operating in a faulty manner and require replacement or repair by specialized technicians. He will also take responsibility for completion of the system (including pipe insulation) and will place it in operating condition.

M. MAINTENANCE

1. Periodic lubrication of moving parts (pumps, blowers, etc).
    a. Locate all components requiring lubrication.
    b. Apply lubrication to components as specified by manufacturers.
2. Filter change.
    a. Remove grill or cover plate as needed.
    b. Remove old filter. Clean with air jet or replace as recommended by manufacturer.
    c. Replace filter and grill or cover.
3. Clean collector glazing.
    a. Home-owner.
4. Descale heat exchangers (water side).
    a. Remove heat exchanger by uncoupling joints or unsoldering.
    b. Flush with descaling agent.
    c. Connect flow meter and pressure gauge and check back pressure. Compare with manufacturers specs.
    d. Replace heat exchanger.
5. Flush open liquid collector loops and refill with clean solution.
    a. Drain fluid from collectors and heat exchangers.
    b. Recharge system with water and drain again.
    c. Fill system with glycol or other recommended solution or fluid.
    d. Insure all drain valves are closed and check pump to insure it is circulating through the collectors.
6. Deleted by experts.
7. Check antifreeze solution strength and PH in liquid closed loop systems.
    a. Drain small quantity of heat exchange fluid into small container.

b. Inspect color and/or check PH with litmus paper or test kit.

c. Check specific gravity of solution with hydrometer (if glycol used).

d. Replace fluid if necessary, or replace lost fluid.

8. Deleted by experts.

9. Replace sacrificial corrosion elements and other system components which are periodically consumed.

   a. Drain fluid from system below level where sacrificial element is located. Insure storage tank is isolated from service water pressure.

   b. Unscrew or remove sacrificial element and replace with new element.

   c. Refill system and place in operating condition.

10. Check tracking orientation of concentrating collectors.

    a. Inspect collectors at various intervals over a day to insure that the focal point of the concentrator is on the collecting surface.

11. Check liquid levels in expansion and storage tanks.

    a. Home owner.

12. Check normal positions of motorized valves and dampers.

    a. See L.2

13. Monitor flowrates and temperature differentials to test system operations.

    a. Check or estimate insolation rate and check flow rate (if flow meter is built in).

    b. Monitor temperature differential across collector by attaching temperature probes to collector inlet/exit.

c. Calculate instantaneous collector efficiency and/or flow rate using manufacturer's collector performance curve and compare all results.

14. Check for degradation of pipeline insulation.

a. Visually inspect pipe insulation exterior.

b. Remove short section of insulation and check for moisture or deterioration.

c. Replace insulation.

15. Check seals on pumps (for leaks).

TOOLS AND EQUIPMENT

(A) Oil can or grease gun.

(B) Plumbing equipment.

(C) Test equipment: Pressure gauge, flow meter, VOM, Hydrometer, PH Test kit, thermometers, simple pyranometers.

(D) Complete tool kit including screw drivers and wrenches.

(E) Ladder.

MATERIALS AND COMPONENTS

(A) Filters.

(B) Descaling agent.

(C) Manufacturer's equipment specification.

(D) Glycol or other heat exchange fluid.

(E) Sacrificial element (anode rod).

REQUIRED KNOWLEDGE

(A) Science

(1) Chemical equilibrium.

(2) Acid-base reactions.

    - (3) Astronomy.
    - (4) Thermodynamics.
    - (5) Electrochemistry.
    - (6) Physics.
- (B) Mathematics.
    - (1) Algebra.
    - (2) Arithmetic

# APPENDIX M

## TASKS ANALYSIS, SOLAR TASKS

This appendix contains a refined analysis of the tasks that require training in solar-related skills. Skills that a worker would need to complete each task are listed and referred to specific tasks.

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| A. CALCULATE HOT WATER LOAD | | | |
| 1. Determine monthly average ground water temperature | a. Obtain ASHRAE Handbook etc., or contact water utility for temperature data. | Library skills<br>Temperature measurement<br>Seasonal variation | Interpret tables |
| 2. Determine design hot water temperature. | a. Determine from building plans what types of appliances are in use, and what water temperatures they require. | Library skills<br>Blueprint reading<br>Temperature | Interpret tables<br>Addition<br>Subtraction |
| 3. Determine hot water requirement for persons. | a. Using Uniform Solar Energy nomography or other reference, apply the number of persons using hot water consumed, or multiply number of persons by 20 gallons per day. | Nomograph interpretation<br>Temperature<br>Energy units | Interpret tables<br>Multiplication<br>Addition<br>Interpret graphs |
| 4. Determine hot water requirement for applicances. | a. Repeat above procedure for appliances using nomograph, or contact manufacturer or distributor of appliances for hot water demand. | Nomography<br>Temperature<br>Energy units | Addition<br>Multiplication<br>Interpret graphs<br>Interpret tables |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| 5. Determine BTU requirement of monthly hot water load. | a. Read BTU requirement from nomograph, or multiply gallons used per day by the design temperature minus the supply water temperature and by 8.3 lbs. per gallon. | Temperature<br>Nomography<br>Heat transfer<br>Specific heat | Multiplication<br>Division<br>Addition<br>Subtraction |
| D. CHOOSE COLLECTOR TYPE | | | |
| 1. Determine average operating collector fluid temperature. | a. Obtain manufacturers' specifications on collector performance. | Energy units<br>Temperature<br>Heat transfer<br>Light transmission<br>Factors effecting efficiency | Interpret graphs<br>Interpret tables |
| | b. From collector manufacturers' specs obtain average operating collector fluid temperature that corresponds to design demands for temperature out of collector. | Temperature<br>Nomography<br>Heat transfer<br>Factors effecting efficiency | Interpret graphs<br>Interpret tables |
| | c. Enter this temperature on work sheet. | | |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| 2. Determine design ambient temperature and insolation. | a. Obtain ASHRAE Handbook of Fundamentals or other source of meteorological and insolation data. | Meteorology<br>Temperature<br>Astronomy | Arithmetic<br>Trigonometry |
|  | b. Look up for design month the ambient temperature and insolation values. | Chart interpretation | Addition<br>Subtraction<br>Multiplication<br>Trigonometric functions<br>Division |
|  | c. Enter values on worksheet. |  |  |
| 3. Determine flat-plate and concentrating collector efficiencies for design conditions. | a. Obtain manufacturer's specifications for collector performance. | Heat transfer<br>Efficiency<br>Insolation<br>Light transmission | Interpret graphs<br>Interpret tables<br>Arithmetic |
|  | b. Read design conditions from worksheet. | Temperature | Interpret tables |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
|  | c. Enter performance graph on bottom axis at point defined by $\frac{T_{in} - T_{ambient}}{\text{Insolation}}$ and go up to curve then horizontally to vertical axis and read collector efficiency. | Temperature<br>Nomography<br>Insolation efficiency | Interpret graphs |
|  | d. Enter results on worksheet. |  |  |
| 4. Determine cost per square foot of collector types. | a. Obtain collector cost from manufacturers or sales outlet. | Interpret value | Arithmetic |
|  | b. Obtain effective solar absorber area from manufacturers literature. | Effective area | Interpret graphs<br>Interpret tables |
|  | c. Divide cost of total collector by effective solar absorber area to get $/ft$^2$ collector. | Interpret value | Division |
|  | d. Enter results in worksheet. |  |  |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| 5. Calculate $/BTU. | a. From D.3 above enter collector efficiency and design insolation in equation below<br>$\frac{\$}{\text{BTU}} = \frac{\text{Cost/Effective Area}}{\text{Insolation x Efficiency}}$ | Energy units<br>Value<br>Effective area<br>Insolation | Equation manipulation<br>Algebra |
| | b. From D.4 above enter collector cost per square foot of absorber area in equation above. | Value<br>Efficiency | Equation manipulation<br>Algebra |
| | c. Solve equation for $\frac{\$}{\text{BTU}}$ | Value<br>Energy Units | Equation manipulation<br>Algebra |
| | d. Enter results in worksheet. | | |
| 6. Choose collector type with lowest energy cost. | a. From list of $/BTU in D.5 above choose collector with lowest $/BTU | Value | Data comparison |
| E. CALCULATE SOLAR GAIN ON UNIT AREA BASIS. | | | |
| 1. Determine collector tilt for application. | a. Find local latitude from maps or atlas. | Map reading<br>Geography<br>Latitude | Interpret graphs |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| | b. Determine solar application from client or blueprints and specifications as to whether it is space heating plus water heating. | Blueprint reading<br>Energy units | |
| | c. If space heating only, a thumb rule for collector tilt plus 15 degrees will be appropriate to make use of the winter sun's position in the sky. | Sun/earth relationship | Arithmetic<br>Trigonometry |
| | d. If water heating only, a thumb rule for collector tilt equal to the latitude will allow year round use of collector. | Sun/earth | Trigonometry |
| | e. If combination of space heating and water heating is required, the tilt is the same as that of space heating only. | Sun/earth | Arithmetic<br>Trignonmetry |
| | f. Enter results in worksheet. | | |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
|  | curve and compare all results. |  |  |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| 2. Determine for each month average hourly insolation for tilt and latitude. | a. Obtain ASHRAE insolation tables. | Energy units<br>Insolation | Interpret tables |
| | b. Obtain local latitude and tilt from E.1 above. | Latitude<br>Tilt | Interpret tables |
| | c. Enter ASHRAE tables for local latitude or closest latitude for which there is a table in the month of January. | Latitude<br>Nomography<br>Meteorology | Interpret tables |
| | d. Read across to tilt closest to that determined in E.1 above. | Tilt<br>Latitude | Interpret tables |
| | e. Enter in worksheet the hourly values for insolation. | | |
| 3. Determine for each month average ambient daylight temperature. | a. Obtain ASHRAE Handbook or other source of temperature data. | Temperature<br>Meteorology<br>Latitude | Interpret tables |
| | b. Enter table for geographic location and list average daily daylight temperature. | Temperature<br>Geography | Interpret tables |

| DUTY TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| 4. Determine monthly collector efficiency from collector performance curve. | a. Obtain manufacturers efficiency curves. | Efficiency<br>Heat transfer | Intrepret graphs |
| | b. Using the following equation<br>$x = \frac{T_{in} - T_{ambient}}{I_{design}}$<br>determine "x" value using design insolation, collector design inlet temperature, and ambient temperature. | Temperature<br>Insolation | Algebra<br>Equation manipulation |
| | c. Enter manufacturer's efficiency curves, then horizontally to vertical axis and read collector efficiency. | Efficiency<br>Nomography | Interpret graphs |
| | d. Follow above procedure for each month of the year. | Temperature<br>Nomography<br>Efficiency | Algebra<br>Interpret graphs |
| 5. Determine monthly clear day collector heat gain in BTU Ft.$^2$ - hr. | a. From E.2 above sum all hourly insolation values greater than $\frac{125 \text{ BTU/hr}}{\text{ft.}^2}$ | Insolation | Addition |

| DUTY TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| | b. Multiply daily clear day insolation (above) by collector efficiency from E.4 above. | Insolation<br>Efficiency | Multiplication |
| 6. Determine for each month average daily daylight collection hours. | a. Obtain ASHRAE Handbook. | Astronomy<br>Sun/earth relationship | Interpret tables |
| | b. Enter tables for closest latitudes and read number of daily daylight hours. | Latitude<br>Sun rotation | Interpret tables |
| 7. Determine haze factor for locality. | a. Obtain local meteorological data from colleges, airports, Federal Government, or State Government, etc. | Meteorology | Interpret tables |
| | b. Look up haze factor for locality. | Meteorology<br>Light scattering<br>Light absorption | Interpret graphs<br>Interpret tables |
| 8. Determine average monthly percent of sunshine. | a. Subtract haze factor % from 100% to obtain % sunshine. | Definition of percentage | Multiplication<br>Subtraction |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| 9. Calculate unit monthly solar gain in BTU/Ft.$^2$, using information obtained in above steps. | | | Algebra |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| F. DETERMINE MAXIMUM AVAILABLE COLLECTOR AREA | | | |
| 1. Determine roof space dimensions. | a. Obtain blueprints or drawings (to scale) of building. | Blueprint reading | Interpret graphs |
| | b. Using engineers or architects scale or actual on site measurement with tape measure, measure all areas of roof that give good southern exposure. | Blueprint reading<br>Area<br>Mensuration | Arithmetic<br>Trigonometry |
| | c. Enter this area on worksheet. | Area | |
| 2. Determine ground space dimensions. | a. Obtain tape measure. | Toolcraft | Basic measuring skill |
| | b. At the site, measure length and width of ground space available for storage tank or collector placement. | Mensuration<br>Length<br>Width | Arithmetic<br>Trigonometry |
| | c. Enter area on worksheet. | Area | |
| 3. Determine shaded spaces. | a. Obtain sun angle locator box. | Toolcraft<br>Simple machines | |
| | b. Positioning yourself so that you are eye level with the bottom of the proposed collector array, use sun angle locator box, positioned parallel with long axis of roof, to find time of year and position of shade devices. | Sun/earth relationship<br>Simple machines | Angles<br>Trigonometry |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| | c. Mark areas that will be shaded on roof/ground diagram. | Simple machines | Arithmetic |
| | d. Measure these areas. | Mensuration | Arithmetic |
| 4. Determine collector physical dimensions. | a. Look up dimensions on manufacturer's specification sheet. | Area<br>Length<br>Width | Interpret tables<br>Arithmetic |
| 5. Allow for proper spacing of collectors on flat roof. | a. Obtain ASHRAE Handbook. | Mensuration<br>Area | Arithmetic |
| | b. Look up solar altitude at 10:00 a.m. on December 21. | Sun/earth relationship | Angle measurement |
| | c. On separate sheet of paper draw to scale, side view of collector array with proper tilt and collector height. | Drafting<br>Tilt | Trigonometry<br>Angle measurement |
| | d. Using protractor, find the point on the north side of collectors where a line drawn at an angle equal to the altitude would just touch the upper edge of the collector. | Simple machines | Trigonometry<br>Angle measurement |
| | e. Measure the distance from the back of the collector array to this point with architects or engineers scale. | Mensuration<br>Length | Linear measurement |
| 6. Allow for proper collector tilt and azimuth. | Tilt<br>Azimuth | Trigonometry | |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| 7. Calculate maximum possible collector area in square feet. | a. Subtract from gross area those areas that were not usable. | Mensuration | Arithmetic |
| G. DETERMINE OPTIMUM COLLECTOR AREA | | | |
| 1. Multiply given collector area by monthly unit solar gain to obtain monthly solar gain in BTU. | a. Obtain collector area from F.7. above. | Energy units<br>Mensuration | |
| | b. Obtain monthly unit solar gain from E.9. | Solar Insolation | Equation manipulation |
| | c. Multiply these numbers together. | Area<br>Solar insolation | Arithmetic |
| 2. Obtain monthly useful solar gain by taking the lesser of the monthly solar gain and the monthly total load. | a. By looking at a column of monthly useful solar gain and a column of monthly total load enter the lesser of the two numbers for each month in a third column. | Nomography | Interpret tables<br>Arithmetic |
| 3. Obtain the typical annual useful solar gain in M BTU by summing the monthly totals and dividing by $10^6$. | a. Add all the numbers in the third column in G.2. above. | Energy units | Arithmetic |
| | b. Divide this number by $10^6$ to obtain M BTU. | Insolation | Arithmetic |
| 4. Determine auxiliary fuel efficiency. | a. Obtain written data on fuel efficiency if possible. | Efficiency | Arithmetic |
| 5. Obtain auxiliary fuel efficiency. | a. Multiply value in G.4. above by annual useful solar gain. | Insolation | Arithmetic |
| 6. Determine cost of solar system. | a. Obtain collector cost information from manufacturers. | Value | Arithmetic |

| DUTY TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| | b. Multiply collector cost by the number of collectors to get solar collector costs. | Value | Multiplication |
| 7. Determine the mortgage interest rate and term. | a. Obtain list of mortgage rates from local building institution. | Mortgage rates | Arithmetic |
| | b. From this list determine mortgage rate based on system cost and lifetime. | | |
| 8. Determine cost and inflation rate of auxiliary fuel. | a. Obtain list or table of local utility rates. | Energy units<br>Costs | Interpret tables |
| | b. From this table determine rate which applies to the specific application (residential, commercial, etc.) | Rate structure | Arithmetic<br>Interpret tables |
| | c. Obtain from local Public Utilities Commission estimates for fuel inflation rates. | | |
| | d. From this information determine which rate applies. | Rate structure | Interpret tables<br>Arithmetic |
| 9. Calculate life cycle value of solar system. | a. Enter data collected above in following formula: | Value | Algebra |
| | $ = Capital cost of solar system | | |
| | (cont'd on following page) | | |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| | $ = Capital cost of solar system including tax incentives or other factors as reflected in $/BTU<br>+<br>present value of fuel cost over lifetime of system<br>+<br>present value of stream of maintenance costs over lifetime of system | | |
| 10. Iterate above steps with different collector areas to obtain maximum life cycle value. | | Value | Algebra |
| H. DESIGN FLUID FLOW SYSTEM | | | |
| 1. Determine proper storage size and location. | a. Locate outside tank in area protected from the elements. Locate inside in tank in mech room insulated from conditioned space if used in summer. | Heat transfer<br>Temperatures<br>Insulation principles | Basic measuring skill |
| | b. Determine application BTU/Hr design load requirements from A, B, & C as applicable. | Heat transfer<br>Temperature | Equation manipulation |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| | c. Determine hours of storage required for application, typically 24 hours for heating and hot water and three to four hours for cooling. | Specific heat<br>Heat transfer | Equation manipulation |
| | d. Determine BTU storage requirement by multiplying hours of storage by BTU/Hr requirement. | Specific heat<br>Heat transfer | Multiplication<br>Equation manipulation |
| | e. Determine design maximum storage temperature and minimum useful storage temperature. | Temperature<br>Heat transfer | Equation manipulation |
| | f. Divide BTU by the difference between maximum and minimum temperatures and divide the result by 8.33 to obtain storage size in gallons.<br>$\text{GAL} = \frac{\text{BTU}}{8.33 \times T}$ | | Division<br>Equation manipulation |
| 2. Integrate solar and conventional systems. | a. For air systems, determine proper location of sola duct tie-ins. For liquid systems, determine location of water coil in conventional ductwork. | Blueprint reading | Basic measuring skills |
| 3. Design system controls and operation modes. | a. Use two stage thermostat to bring on solar first and conventional equipment second. | Control theory<br>Flow of electrical current | |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| | b. Use temperature sensors and relays to prevent the circulation of the solar working fluid to the load when the fluid is not hot enough to help meet the load. | Temperatures<br>Electrical circuitry | Interpret diagrams |
| | c. Use a differential control and sensors to ensure that the solar collectors recharge storage and do not degrade it. | Electrical circuitry<br>Bi-metal principles | |
| | d. Use a motorized valve or check valve to ensure that storage is not degraded by thermal siphoning backflow. | Fluid flow<br>Electrical circuitry | Interpret diagrams |
| | e, Include relief valves, air vents, vacuum breakers, and tempering valves as necessary. | Piping design | Arithmetic |
| 4. Size individual system components in accordance with collector size and load requirements. | a. Determine CFM and GPM for conventional equipment and solar collectors. | Pump characteristics<br>Fluid flow<br>Fan characteristics | Equation manipulation<br>Arithmetic<br>Interpret tables |
| | b. For liquid systems, choose water coil that meets BTU/Hr load requirements at design minimum useful solar supply water temperature. | Temperature<br>Heat transfer<br>Fluid flow | Arithmetic<br>Algebra<br>Comparison |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| | c. For air systems, choose air to water exchanger to meet domestic hot water requirements at collector design CFM and outlet temperatures. | Temperature<br>Heat transfer<br>Fluid flow | Algebra<br>Arithmetic<br>Comparison |
| | d. For liquid systems requiring a water to water heat exchanger between the collector and storage, determine collector fluid specific heat, GPM, and outlet temperature; and determine tank minimum flow over the exchanger surface and design inlet temperature. Refer to manufacturer for exchanger size. | Specific heat<br>Temperature<br>Heat transfer<br>Fluid flow | Algebra<br>Arithmetic |
| | e. Design duct and pipe sizes for required CFM and GPM not exceeding friction loss and velocity limits specified in ASHRAE handbook. | Fluid flow<br>Piping design<br>Duct design | Algebra<br>Arithmetic<br>Equation manipulation<br>Interpret graphs<br>Interpret tables |
| | f. Choose the smallest pump and fan models that exceed or equal design CFM and GPM at required static pressure and head. | Fluid flow<br>Nomography<br>Pump characteristics<br>Fan characteristics | Interpret graphs<br>Comparison<br>Interpret tables |
| 5. Prepare working drawings. | a. Determine schematic representation of system components: pipelines, valves, dampers, fans, pumps, storage, collectors, conventional equipment, etc. | System design<br>Drafting | Interpret diagrams |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
|  | b. Draw wiring diagrams linking thermostats, relays, temperature sensors, and mechanical system components. | Electrical circuitry<br>Drafting | Interpret diagrams |
|  | c. Use building plans to determine physical location of components. | Blueprint reading | Interpret plans |
| 6. Prepare materials and equipment specifications. | a. Determine lengths of various duct and pipe sizes needed. | Mensuration | Arithmetic<br>Trigonometry |
|  | b. Determine number and sizes of elbows, tees, gate valves, manual dampers, registers, and other small passive fittings for pipeline connections. | Mensuration | Arithmetic |
|  | c. Determine number and sizes of motorized valves and dampers, pumps, fans, differential controls, thermostats, relays, relief valves, vacuum breakers, air vents, expansion and compression tanks, aquastats, and other small active system components. | Mensuration | Arithmetic |
|  | d. Determine number and model of collectors, furnaces, air conditioning units, storage tanks, or other large system equipment. | Mensuration | Arithmetic<br>Interpret charts |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| J. INSTALL COLLECTOR | | | |
| 3. Mount each collector. | a. Obtain collectors from manufacturer. | Human relations | Interpret graphs<br>Interpret charts |
| | b. Raise collector onto roof. | Mechanical advantage<br>Simple machines<br>Coefficient of friction | |
| | c. Place collector on mounting being careful not to damage copper heads or mountings. | Mechanical advantage<br>Simple machines | Basic measuring skills |
| | d. Fasten collector to mounting per blueprints. | Knowledge of fasteners<br>Simple machines<br>Blueprint reading | Interpret diagrams |
| L. SYSTEM CHECKOUT | | | |
| 2. Check out the system powered components. | a. Insure power is delivered to system components. | Flow of electrical current | Basic measuring skills<br>Interpret meter scales |
| | b. Place system in all possible operating modes by manually switching control and/or shorting sensor wires. | Control theory<br>Flow of electrical current<br>Interpret wiring diagrams | |
| | c. Check operation of pumps, automatic valves and other components in all modes to insure their operation complies with the intended mode of operation. | Flow of electrical current<br>Fluid flow<br>Airflow<br>Solenoid operation | Interpret scales |
| | d. Return control overrides to normal position. | | |

| DUTY<br>TASK | ACTIVITY | SCIENCE SKILLS | MATHEMATICS SKILLS |
|---|---|---|---|
| 4. Calibrate and test solar temperature differential controls. | a. If control system is factory calibrated, inspect operation of system under various temperature and insolation conditions. Insure that system is operating in proper modes. | Temperature<br>Solar insolation measurement<br>Fluid expansion & contraction<br>Bi-metal principles | Interpret scales |
| | b. If control is not factory calibrated, test by immersing sensors in water at various temperatures. Monitor water temperature with thermometer and check differential on and off temperatures and high or low limit functions. Use VOM to check position of relays. | Temperature<br>Bi-metal principles<br>Flow of electrical current | Interpret thermometer scales |
| M. MAINTENANCE | | | |
| 12. Check normal positions of motorized valves and dampers. | a. See L.2 | | |
| 13. Monitor flowrates and temperature differentials to test system operations. | a. Check or estimate insolation rate and check flow rate (if flow meter is built in). | Solar insolation measurement<br>Fluid flow<br>Pressure drop | Interpret scales |
| | b. Monitor temperature differential across collector by attaching temperature probes to collector inlet/exit. | Temperature<br>Temperature measurement<br>Thermocouple principles | Interpret scales |
| | c. Calculate instantaneous collector efficiency and/or flow rate using manufacturer's collector performance | Efficiency<br>Fluid flow<br>Heat transfer | Equation manipulation<br>Interpret charts |

Appendix 2

V-TECS

VOCATIONAL-TECHNICAL
EDUCATION CONSORTIUM
OF STATES

# SOLAR HEATING MECHANIC
# OCCUPATIONAL INVENTORY

MEMBERS:
Alabama
Florida
Georgia
Illinois
Indiana
Kentucky
Louisiana
Maryland
Michigan
Mississippi
New York
Pennsylvania
South Carolina
Tennessee
Virginia
West Virginia
Wisconsin

U.S. Air Force
U.S. Army
U.S. Navy

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ERVICES RENDERED

- Educational Planning
- Needs Assessments
- Management Studies
- Educational Program Evaluations
- School District Policy
- Educational Specifications
- Long-Range Developmental Programs
- In-Service Programs
- Staff Evaluations
- Negotiations
- Procurement of Superintendents and other Administrative Supervisory Personnel
- Public Relations
- Vocational Education Systems
- Product Evaluations
- Curriculum Development

Dear Solar Heating Mechanic:

We need your help! In conjunction with the Pennsylvania Department of Education, we are conducting a study which we believe you will find interesting and helpful to your profession. We are trying to compile a complete list of jobs and tasks performed by Solar Heating Mechanics. This information will be used to improve and update the quality of training programs to prepare Solar Heating Mechanics.

We are asking you to help us determine if the equipment and task lists are complete and accurate. The following page gives directions for checking and rating the equipment and tasks.

A stamped, self-addressed envelope is enclosed for your convenience in returning the survey.

Your experience and knowledge are very important to this effort, especially since solar heating is such a new field. We are counting on your help.

Sincerely,

ASSOCIATED EDUCATIONAL CONSULTANTS, INC.

Dan K. Jacobs

Dan K. Jacobs, Ed.D.
Vice President

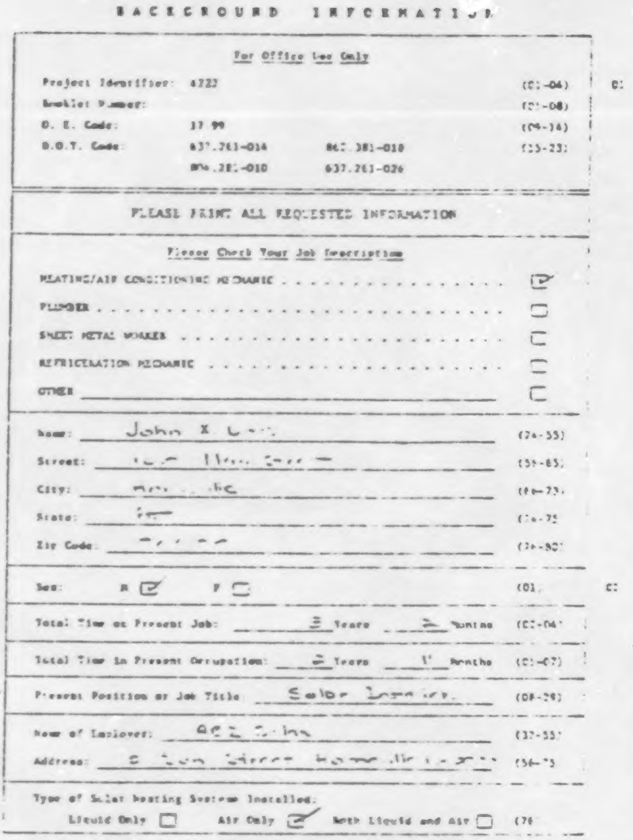
DKJ/mpw

# DIRECTIONS

PART 1 - IS THE BACKGROUND INFORMATION SHEET. IT LOOKS LIKE THE PAGE TO THE RIGHT. YOUR ANSWERS WILL BE COMBINED WITH MANY OTHERS FROM THE FIELD OF SOLAR HEATING. NO REFERENCE WILL BE MADE TO YOUR INDIVIDUAL ANSWERS.

ALL INFORMATION YOU GIVE WILL BE KEPT IN STRICT CONFIDENCE.

FIRST STEP - PLEASE FILL IN THE "BACKGROUND INFORMATION SHEET" WHICH FOLLOWS THIS PAGE.



BACKGROUND INFORMATION

For Office Use Only

Project Identifier: 4723 (01-04)
Booklet Number: (05-08)
O. E. Code: 17.99 (09-14)
D.O.T. Code: 637.261-014 862.381-010 (15-23)
869.281-010 637.261-026

PLEASE PRINT ALL REQUESTED INFORMATION

Please Check Your Job Description

HEATING/AIR CONDITIONING MECHANIC . . . . . . . . . . . . . . . . ☑
PLUMBER . . . . . . . . . . . . . . . . . . . . . . . . . . ☐
SHEET METAL WORKER . . . . . . . . . . . . . . . . . . . . . ☐
REFRIGERATION MECHANIC . . . . . . . . . . . . . . . . . . . ☐
OTHER ______________ ☐

Name: John X [illegible] (24-55)
Street: [illegible] (56-65)
City: [illegible] (66-73)
State: [illegible] (74-75)
Zip Code: [illegible] (76-80)

Sex: M ☑ F ☐ (01)

Total Time on Present Job: 3 Years 2 Months (02-04)

Total Time in Present Occupation: 2 Years 1 Months (05-07)

Present Position or Job Title: Solar [illegible] (08-29)

Name of Employer: [illegible] (30-55)
Address: [illegible] (56-75)

Type of Solar heating Systems Installed:
Liquid Only ☐ Air Only ☑ Both Liquid and Air ☐ (76)

# BACKGROUND INFORMATION

**For Office Use Only**

Project Identifier: 4222 (01-04) 01

Booklet Number: (05-08)

O. E. Code: 17.99 (09-14)

D.O.T. Code: 637.261-014 862.381-018 (15-23)

804.281-010 637.261-026

PLEASE PRINT ALL REQUESTED INFORMATION

**Please Check Your Job Description**

HEATING/AIR CONDITIONING MECHANIC . . . . . . . . . . . . . . . . . ☐

PLUMBER . . . . . . . . . . . . . . . . . . . . . . . . . . . . ☐

SHEET METAL WORKER . . . . . . . . . . . . . . . . . . . . . . ☐

REFRIGERATION MECHANIC . . . . . . . . . . . . . . . . . . . . ☐

OTHER ______________________________

Name: ______________________________ (24-55)

Street: ______________________________ (56-65)

City: ______________________________ (66-73)

State: ______________________________ (74-75)

Zip Code: ______________________________ (76-80)

Sex: M ☐ F ☐ (01) 02

Total Time on Present Job: ______ Years ______ Months (02-04)

Total Time in Present Occupation: ______ Years ______ Months (05-07)

Present Position or Job Title: ______________________________ (08-29)

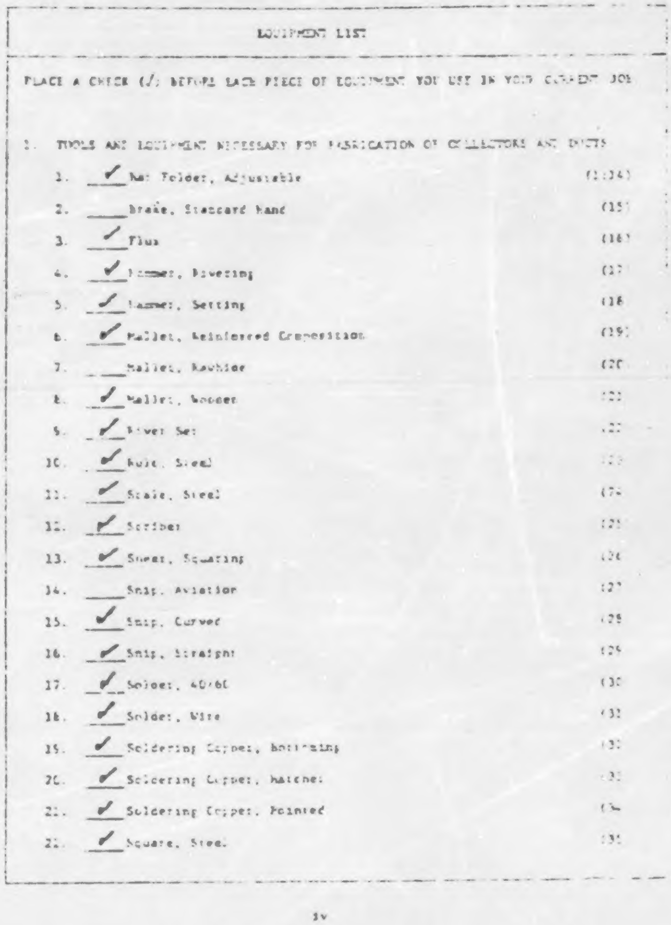
Name of Employer: ______________________________ (32-55)

Address: ______________________________ (56-75)

Type of Solar Heating Systems Installed:
Liquid Only ☐ Air Only ☐ Both Liquid and Air ☐ (76)

# DIRECTIONS

PART 2 - IS THE EQUIPMENT LIST. IT LOOKS LIKE THE PAGE AT THE RIGHT. PLEASE PLACE A CHECK MARK BY EACH PIECE OF EQUIPMENT YOU USE IN YOUR CURRENT JOB.



EQUIPMENT LIST

PLACE A CHECK (✓) BEFORE EACH PIECE OF EQUIPMENT YOU USE IN YOUR CURRENT JOB

I. TOOLS AND EQUIPMENT NECESSARY FOR FABRICATION OF COLLECTORS AND DUCTS

1. ✓ Bar Folder, Adjustable (1:14)
2. ___ Brake, Standard Hand (15)
3. ✓ Flux (16)
4. ✓ Hammer, Riveting (17)
5. ✓ Hammer, Setting (18)
6. ✓ Mallet, Reinforced Composition (19)
7. ___ Mallet, Rawhide (20)
8. ✓ Mallet, Wooden (21)
9. ✓ Rivet Set (22)
10. ✓ Rule, Steel (23)
11. ✓ Scale, Steel (24)
12. ✓ Scriber (25)
13. ✓ Shear, Squaring (26)
14. ___ Snip, Aviation (27)
15. ✓ Snip, Curved (28)
16. ✓ Snip, Straight (29)
17. ✓ Solder, 40/60 (30)
18. ✓ Solder, Wire (31)
19. ✓ Soldering Copper, Bottoming (32)
20. ✓ Soldering Copper, Hatchet (33)
21. ✓ Soldering Copper, Pointed (34)
22. ✓ Square, Steel (35)

iv

PLEASE TURN TO PAGE iv AND COMPLETE THE EQUIPMENT LIST.

## EQUIPMENT LIST

PLACE A CHECK (✓) BEFORE EACH PIECE OF EQUIPMENT YOU USE IN YOUR CURRENT JOB.

### I. TOOLS AND EQUIPMENT NECESSARY FOR FABRICATION OF COLLECTORS AND DUCTS

1. ____Bar Folder, Adjustable (1:14)
2. ____Brake, Standard Hand (15)
3. ____Flux (16)
4. ____Hammer, Riveting (17)
5. ____Hammer, Setting (18)
6. ____Mallet, Reinforced Composition (19)
7. ____Mallet, Rawhide (20)
8. ____Mallet, Wooden (21)
9. ____Rivet Set (22)
10. ____Rule, Steel (23)
11. ____Scale, Steel (24)
12. ____Scriber (25)
13. ____Shear, Squaring (26)
14. ____Snip, Aviation (27)
15. ____Snip, Curved (28)
16. ____Snip, Straight (29)
17. ____Solder, 40/60 (30)
18. ____Solder, Wire (31)
19. ____Soldering Copper, Bottoming (32)
20. ____Soldering Copper, Hatchet (33)
21. ____Soldering Copper, Pointed (34)
22. ____Square, Steel (35)

## EQUIPMENT LIST

PLACE A CHECK (✓) BEFORE EACH PIECE OF EQUIPMENT YOU USE IN YOUR CURRENT JOB.

23. ____Square, Try (36)

24. ____Stake, Beak Horn (37)

25. ____Stake, Blow Horn (38)

26. ____Stake, Candle Mould (39)

27. ____Stake, Hollow Mandrel (40)

28. ____Welder, Arc (41)

29. ____Welder, Oxy-Acetylene (42)

### II. TOOLS NECESSARY FOR COLLECTOR START-UP

30. ____Awl, Scratch (43)

31. ____Cable (44)

32. ____Caulk Line (45)

33. ____Come-along (46)

34. ____Cord, Extension (47)

35. ____Crane, Front Loader (48)

36. ____Drill, Electric 1/4 Inch (49)

37. ____Drill, Electric 3/8 Inch (50)

38. ____Drill, Electric 1/2 Inch (51)

39. ____Extension, Drill (52)

40. ____Gloves, Work (53)

41. ____Jack, Roof (54)

42. ____Helmet, Safety (55)

43. ____Pliers, Combination (56)

# EQUIPMENT LIST

PLACE A CHECK (✓) BEFORE EACH PIECE OF EQUIPMENT YOU USE IN YOUR CURRENT JOB.

44. ____Pliers, Straight Nose (57)
45. ____Rope, Safety (58)
46. ____Saw, Sabre (59)
47. ____Screwdrivers, Phillips (60)
48. ____Screwdrivers, Standard Bit (61)
49. ____Sockets, Hex (62)
50. ____Tape, Steel (63)
51. ____Tool Set, Pull-up (64)
52. ____Walkie-Talkie (65)

## III. TOOLS NECESSARY FOR DUCT START-UP

53. ____Cutter, Hole (66)
54. ____Gun, Caulk (67)
55. ____Hammer, Claw (68)
56. ____Knife, Utility (69)
57. ____Light, Portable (70)
58. ____Notchers (71)
59. ____Screw Holder, Hex Head (72)
60. ____Seamers, Hand (73)
61. ____Snips, Left (74)
62. ____Snips, Right (75)
63. ____Tool Set, Fiberglass Duct Board Cutting (76)

## EQUIPMENT LIST

PLACE A CHECK (✓) BEFORE EACH PIECE OF EQUIPMENT YOU USE IN YOUR CURRENT JOB.

### IV. TOOLS NECESSARY FOR PLUMBING START-UP

64. ____Block, Flaring (77)
65. ____Chisels, Assorted Cold Steel (78)
66. ____Clamp, Compression (79)
67. ____Clamp, Pipe (80)
68. ____Cutter, Pipe (2:1)
69. ____Die (2)
70. ____Files, Assorted (3)
71. ____Hammer, Ball Peen (4)
72. ____Pliers, Diagonal Cutting (5)
73. ____Pliers, Needle Nose (6)
74. ____Reamer (7)
75. ____Sandpaper (8)
76. ____Saw, Hack (9)
77. ____Tape, Teflon (10)
78. ____Torch, Acetylene (11)
79. ____Torch, Propane (12)
80. ____Tool Set, Flaring (13)
81. ____Tool Set, Pipe Threading (14)
82. ____Vise, Hand (15)
83. ____Wrench, Crescent (16)

## EQUIPMENT LIST

PLACE A CHECK (✓) BEFORE EACH PIECE OF EQUIPMENT YOU USE IN YOUR CURRENT JOB.

84. ____Wrench, Vise Grip (17)
85. ____Wrenches, Flare-fitting (18)
86. ____Wrenches, Open-End Nut (19)
87. ____Wrenches, Pipe (20)

### V. TOOLS NECESSARY FOR SYSTEM START-UP

88. ____Amprobe, V-O-M (21)
89. ____Bolts and Nuts (22)
90. ____Drill, Battery-powered (23)
91. ____Drivers, Nut (24)
92. ____Fuses (25)
93. ____Gauges Magnehelic (26)
94. ____Meter, Amp (27)
95. ____Sockets and Ratchet (28)
96. ____Tape, Electrical (29)
97. ____Thermometer (30)
98. ____Washers (31)
99. ____Wire (32)

NOTE: IF YOU USE EQUIPMENT WHICH IS NOT LISTED, WRITE IT IN THE SPACE BELOW.

100. ____ ______________________________
101. ____ ______________________________

## EQUIPMENT LIST

IF YOU USE EQUIPMENT WHICH IS NOT LISTED, WRITE IT IN THE SPACE BELOW.

102. ____ ______________________________

103. ____ ______________________________

104. ____ ______________________________

105. ____ ______________________________

106. ____ ______________________________

107. ____ ______________________________

108. ____ ______________________________

109. ____ ______________________________

110. ____ ______________________________

111. ____ ______________________________

112. ____ ______________________________

113. ____ ______________________________

114. ____ ______________________________

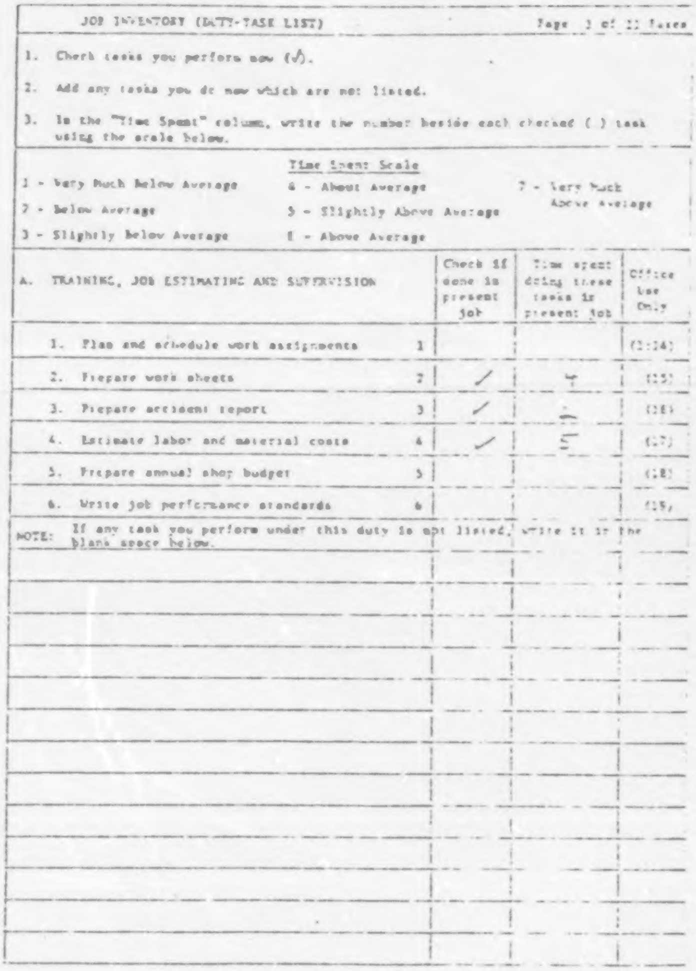
115. ____ ______________________________

# D I R E C T I O N S

PART 3 - IS THE "TASK LIST". WE NEED TO KNOW TWO THINGS. (1) THE TASKS YOU PERFORM, AND (2) THE TIME YOU SPEND PERFORMING THEM.

STEP 1 - AS YOU READ EACH TASK, PLACE A CHECK MARK BESIDE EACH TASK IN THE FIRST DUTY THAT YOU DO IN YOUR PRESENT JOB. DO THIS STEP NOW. WHEN YOU FINISH, COME BACK TO STEP 2.

STEP 2 - NOW YOU ARE TO RATE THE AMOUNT OF TIME YOU SPEND PERFORMING EACH TASK. USE A SCALE OF "1" TO "7". USE A "1" IF YOU SPEND "VERY MUCH BELOW AVERAGE" TIME ON A TASK. USE A "2" FOR "BELOW AVERAGE" AND SO ON, UP TO A RATING OF "7" IF YOU SPEND VERY MUCH ABOVE AVERAGE AMOUNT OF TIME ON THE TASK. DO THIS STEP NOW.



JOB INVENTORY (DUTY-TASK LIST) Page 3 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column, write the number beside each checked ( ) task using the scale below.

Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - About Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| A. TRAINING, JOB ESTIMATING AND SUPERVISION | | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|---|
| 1. Plan and schedule work assignments | 1 | | | (2:14) |
| 2. Prepare work sheets | 2 | ✓ | 4 | (15) |
| 3. Prepare accident report | 3 | ✓ | 2 | (16) |
| 4. Estimate labor and material costs | 4 | ✓ | 5 | (17) |
| 5. Prepare annual shop budget | 5 | | | (18) |
| 6. Write job performance standards | 6 | | | (19) |

NOTE: If any task you perform under this duty is not listed, write it in the blank space below.

REPEAT STEPS 1 AND 2 FOR THE REMAINING DUTIES. WHEN YOU HAVE COMPLETED ALL YOUR RATINGS, YOU WILL HAVE COMPLETED THE OCCUPATIONAL INVENTORY. YOU SHOULD THEN PLACE IT IN THE SELF-ADDRESSED, STAMPED ENVELOPE AND MAIL IT BACK TO US. THANK YOU.

JOB INVENTORY (DUTY-TASK LIST) Page 1 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column, write the number beside each checked (✓) task using the scale below.

### Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - About Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| A. TRAINING, JOB ESTIMATING AND SUPERVISION | | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|---|
| 1. Plan and schedule work assignments | 1 | | | (1:14) |
| 2. Prepare work sheets | 2 | | | (15) |
| 3. Prepare accident report | 3 | | | (16) |
| 4. Estimate labor and material costs | 4 | | | (17) |
| 5. Prepare annual shop budget | 5 | | | (18) |
| 6. Write job performance standards | 6 | | | (19) |
| NOTE: If any task you perform under this duty is not listed, write it in the blank space below. | | | | |
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| | | | | |
| B. SERVICING SOLAR HEATING AND COOLING SYSTEMS | | | | |
| 1. Drain and fill liquid system with corrosion inhibitors | 7 | | | (20) |
| 2. Drain and fill liquid system with antifreeze | 8 | | | (21) |
| 3. Drain and fill liquid system with silicone | 9 | | | (22) |

JOB INVENTORY (DUTY-TASK LIST) Page 2 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column, write the number beside each checked (✓) task using the scale below.

Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - About Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| B. SERVICING SOLAR HEATING AND COOLING SYSTEMS (Continued) | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|
| 4. Drain and fill absorption system with | | | |
| Lithium-bromide-water solution 10 | | | (23) |
| 5. Drain and fill absorption system | | | |
| with Ammonia-water solution 11 | | | (24) |
| NOTE: If any task you perform under this duty is not listed, write it in the | | | |
| blank space below. | | | |
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| | | | |
| C. CONSTRUCTING AND MOUNTING SOLAR FLAT PLATE | | | |
| COLLECTOR PANELS | | | |
| 1. Fabricate galvanized steel collector | | | |
| frame 12 | | | (25) |
| 2. Fabricate aluminum collector frame 13 | | | (26) |
| 3. Fabricate wood collector frame 14 | | | (27) |
| 4. Insulate collector frame 15 | | | (28) |
| 5. Fabricate aluminum collector | | | |
| absorber plate 16 | | | (29) |

JOB INVENTORY (DUTY-TASK LIST) Page 3 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column write the number beside each checked (✓) task using the scale below.

Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - Above Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| C. CONSTRUCTING AND MOUNTING SOLAR FLAT PLATE COLLECTOR PANELS (Continued) | | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|---|
| 6. Fabricate copper collector absorber plate | 17 | | | (1:30) |
| 7. Fabricate steel plate collector absorber plate | 18 | | | (31) |
| 8. Paint collector absorber plate | 19 | | | (32) |
| 9. Glaze collector glass cover | 20 | | | (33) |
| 10. Glaze collector plastic cover | 21 | | | (34) |
| 11. Fabricate inlet and outlet collector manifolds | 22 | | | (35) |
| 12. Install getter column | 23 | | | (36) |
| 13. Install air vent | 24 | | | (37) |
| 14. Install vacuum relief valve | 25 | | | (38) |
| 15. Install manual fill valve | 26 | | | (39) |
| 16. Install plumbing flashing on roof | 27 | | | (40) |
| 17. Install collector panel on director mounting | 28 | | | (41) |
| 18. Install collector panel on flat roof rack mounting | 29 | | | (42) |
| 19. Install collector panel on stand-off mounting | 30 | | | (43) |

JOB INVENTORY (DUTY-TASK LIST) Page 4 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column write the number beside each checked (✓) task using the scale below.

Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - About Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| C. CONSTRUCTING AND MOUNTING SOLAR FLAT PLATE COLLECTOR PANELS (Continued) | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|
| NOTE: If any task you perform uner this duty is not listed, write it in the |  |  |  |
| blank space below. |  |  |  |
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| D. INSTALLING LIQUID TRANSFER LINES |  |  |  |
| 1. Install galvanized steel transfer piping 31 |  |  | (1:44) |
| 2. Install copper transfer piping 32 |  |  | (45) |
| 3. Install plastic transfer piping 33 |  |  | (46) |
| 4. Install Dielectric union 34 |  |  | (47) |
| 5. Connect neoprene hose to piping 35 |  |  | (48) |
| 6. Insulate piping and fittings 36 |  |  | (49) |
| NOTE: If any task you perform under this duty is not listed, write it in the |  |  |  |
| blank space below. |  |  |  |
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JOB INVENTORY (DUTY-TASK LIST) Page 5 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column write the number beside each checked (✓) task using the scale below.

Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - About Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| E. FABRICATING LIQUID HEAT STORAGE UNITS | | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|---|
| 1. Fabricate storage unit foundation from | | | | |
| concrete blocks and wood | 37 | | | (1:50) |
| 2. Install concrete storage tank | 38 | | | (51) |
| 3. Insulate concrete storage tank with | | | | |
| rigid foam sheeting | 39 | | | (52) |
| 4. Apply high temperature sealant on | | | | |
| interior surface of concrete tank | 40 | | | (53) |
| 5. Install fiberglass tank | 41 | | | (54) |
| 6. Install galvanized steel tank | 42 | | | (55) |
| 7. Install heat exchanger | 43 | | | (56) |
| 8. Connect piping from water-pressurized | | | | |
| storage tank to outside vent | 44 | | | (57) |
| 9. Install pressure relief valve on | | | | |
| pressurized storage tank | 45 | | | (58) |
| 10. Install float controlled valve on | | | | |
| nonpressurized storage tank | 46 | | | (59) |
| 11. Install drain valve | 47 | | | (60) |
| 12. Install thermistor sensor | 48 | | | (61) |
| 13. Insulate storage tank and fittings | 49 | | | (62) |
| 14. Install mixing valve | 50 | | | (63) |

JOB INVENTORY (DUTY-TASK LIST) Page 6 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column write the number beside each checked (✓) task using the scale below.

Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - About Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| E. FABRICATING LIQUID HEAT STORAGE UNITS (Cont'd.) | | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|---|
| 15. Install shut-off valve | 51 | | | (1:64) |
| 16. Install expansion tank | 52 | | | (65) |
| 17. Install air eliminator | 53 | | | (66) |
| 18. Install pressure gauge | 54 | | | (67) |
| 19. Install preheat tank | 55 | | | (68) |
| 20. Connect auxiliary water heater to | | | | |
| preheat or storage tank | 56 | | | (69) |
| NOTE: If any task you perform under this duty is not listed, write it in the | | | | |
| blank space below. | | | | |
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| F. FABRICATING AIR HEAT STORAGE UNITS | | | | |
| 1. Fabricate pebble-bed storage unit | | | | |
| using wood and wire | 57 | | | (70) |
| 2. Insulate wooden storage unit | 58 | | | (71) |
| 3. Assemble steel bin pebble-bed | | | | |
| storage unit | 59 | | | (72) |

JOB INVENTORY (DUTY-TASK LIST) Page 7 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" Column write the number beside each checked (✓) task using the scale below.

Time Spent Scale

| | | |
|---|---|---|
| 1 - Very Much Below Average | 4 - About Average | 7 - Very Much Above Average |
| 2 - Below Average | 5 - Slightly Above Average | |
| 3 - Slightly Below Average | 6 - Above Agerage | |

| F. FABRICATING AIR HEAT STORAGE UNITS (Cont'd) | | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|---|
| 4. Insulate steel storage unit | 60 | | | (1:73) |
| 5. Construct block and concrete | | | | |
| pebble-bed storage unit | 61 | | | (74) |
| 6. Insulate cement block storage unit | 62 | | | (75) |
| 7. Construct concrete form pebble-bed | | | | |
| storage unit | 63 | | | (76) |
| 8. Insulate concrete form storage unit | 64 | | | (77) |
| 9. Line pebble-bed storage unit with | | | | |
| bond beam blocks | 65 | | | (78) |
| 10. Install wire screen in pebble-bed | | | | |
| storage unit | 66 | | | (79) |
| 11. Fill pebble-bed storage unit | 67 | | | (80) |
| 12. Fabricate and fill plastic salt | | | | |
| hydrate containers | 68 | | | (2:1) |
| 13. Fabricate insulated support structure | | | | |
| for plastic containers | 69 | | | (2) |
| 14. Fabricate insulated frame for brick | | | | |
| storage unit | 70 | | | (3) |
| 15. Align 10-core brick in insualted frame | 71 | | | (4) |

JOB INVENTORY (DUTY-TASK LIST) Page 8 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column write the number beside each checked (✓) task using the scale below.

Time Spent Scale

1 - Very Much Below Average

2 - Below Average

3 - Slightly Below Average

4 - About Average

5 - Slightly Above Average

6 - Above Average

7 - Very Much Above Average

| F. FABRICATING AIR HEAT STORAGE UNITS (Cont'd) | | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|---|
| NOTE: If any task you perform under this duty is not listed, write it in | | | | |
| the blank space below. | | | | |
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| G. INSTALLING MEDIA TRANSFER SYSTEMS | | | | |
| 1. Connect liquid heat pump | 72 | | | (2:5) |
| 2. Connect air heat pump | 73 | | | (6) |
| 3. Install collector fan | 74 | | | (7) |
| 4. Install distribution fan | 75 | | | (8) |
| 5. Install fan coil unit | 76 | | | (9) |
| 6. Install centrifugal pump | 77 | | | (10) |
| 7. Install air handling unit | 78 | | | (11) |
| 8. Install swing check valve | 79 | | | (12) |
| 9. Install pressure-reducing valve | 80 | | | (13) |
| 10. Install automatic system fill valve | 81 | | | (14) |
| 11. Install flow balancing valve | 82 | | | (15) |
| 12. Install generator | 83 | | | (16) |

JOB INVENTORY (DUTY-TASK LIST) Page 9 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column write the number beside each checked (✓) task using the scale below.

Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - About Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| G. INSTALLING MEDIA TRANSFER SYSTEMS (Continued) | | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|---|
| 13. Install condenser | 84 | | | (2:17) |
| 14. Install expansion valve | 85 | | | (18) |
| 15. Install evaporator | 86 | | | (19) |
| 16. Install evaporator cooler | 87 | | | (20) |
| 17. Install absorber | 88 | | | (21) |
| 18. Install cooling tower | 89 | | | (22) |
| 19. Install heat exchanger | 90 | | | (23) |
| 20. Install water preheat coil | 91 | | | (24) |
| 21. Fabricate ductwork | 92 | | | (25) |
| 22. Install ductwork | 93 | | | (26) |
| 23. Install filter in ductwork | 94 | | | (27) |
| 24. Install finned duct coils | 95 | | | (28) |
| 25. Install damper | 96 | | | (29) |
| 26. Install centrifugal blower | 97 | | | (30) |

NOTE: If any task you perform under this duty is not listed, write it in the blank space below.

JOB INVENTORY (DUTY-TASK LIST) Page 10 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed.
3. In the "Time Spent" column write the number beside each checked (✓) task using the scale below.

Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - About Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| H. SERVICING ELECTRICAL SYSTEMS | | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|---|
| 1. Install electrical fuse box | 98 | | | (2:31) |
| 2. Install circuit-breaker box | 99 | | | (32) |
| 3. Connect electrical wiring to plugs | 100 | | | (33) |
| 4. Install electrical cleat sockets | 101 | | | (34) |
| 5. Install electrical base-pull sockets | 102 | | | (35) |
| 6. Install electrical weatherproof sockets | 103 | | | (36) |
| 7. Install terminal | 104 | | | (37) |
| 8. Install junction box | 105 | | | (38) |
| 9. Install panel switch | 106 | | | (39) |
| 10. Install two-stage heating/single-stage cooling thermostat | 107 | | | (40) |
| 11. Install differential controller | 108 | | | (41) |
| 12. Install outdoor reset controller | 109 | | | (42) |
| 13. Install collector temperature sensor | 110 | | | (43) |
| 14. Install frost sensor | 111 | | | (44) |
| 15. Install upperlimit sensor | 112 | | | (45) |
| 16. Install electrical ground wire | 113 | | | (46) |
| 17. Install damper motor | 114 | | | (47) |
| 18. Install generator motor | 115 | | | (48) |

JOB INVENTORY (DUTY-TASK LIST) Page 11 of 11 Pages

1. Check tasks you perform now (✓).
2. Add any tasks you do now which are not listed
3. In the "Time Spent" column write the number beside each checked (✓) task using the scale below.

Time Spent Scale

1 - Very Much Below Average
2 - Below Average
3 - Slightly Below Average
4 - About Average
5 - Slightly Above Average
6 - Above Average
7 - Very Much Above Average

| H. SERVICING ELECTRICAL SYSTEMS (Continued) | Check if done in present job | Time spent doing these tasks in present job | Office Use Only |
|---|---|---|---|
| NOTE: If any task you perform under this duty is not listed, write it in | | | |
| the blank space below. | | | |
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| THANK YOU FOR YOUR COOPERATION | | | |
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